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# NUCLEAR SCIENCE ABSTRACTS

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Volume 16, Number 23 December 15, 1962

# NUCLEAR SCIENCE ABSTRACTS

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# NUCLEAR SCIENCE ABSTRACTS

## GENERAL AND MISCELLANEOUS

**31350** (KR-22) QUARTERLY PROGRESS REPORT [ON RESEARCH] JANUARY–FEBRUARY–MARCH 1962. (Norway. Institutt for Atomenergi, Kjeller). June 1962. 57p.

Five fuel elements were removed from the JEEP which showed signs of cladding failure. These elements were at a burnup of 250 Mwd/t. The NORA reactor was used for transfer function measurements with elements for the second charge in the Halden Reactor. Design and development of water level gage for the Halden Reactor are reported. Progress was made in establishing a mathematical model for the dynamics of the Halden core. The steel containment shell and the control and service building for the JEEP II are almost complete. Data obtained in neutron diffraction studies on $Cr_2Te_3$ and Fe 1.17 Te structures are included. Corrosion testing of Al was continued. Reprocessing pilot plant test runs revealed that scrub acidity has a marked effect on the decontamination factors for gross gamma, beta, and RU. Reversed-phase partition chromatography was used for the isolation of Pu from irradiated U solutions. Production of isotopes is steadily increasing, and a method for production of high specific-activity $Cr^{51}$ was developed. (J.R.D.)

**31351** (LADC-5378) A PROPOSAL FOR AN INTERNATIONAL HELIUM-3 VAPOR PRESSURE SCALE OF TEMPERATURES. S. G. Sydoriak, T. R. Roberts, R. H. Sherman (Los Alamos Scientific Lab., N. Mex.); and F. G. Brickwedde (Pennsylvania State Univ., University Park). [nd]. Contract [W-7405-eng-36]. 10p.

A scale of temperatures based on a relation between temperature and the vapor pressure of liquid $He^3$, extending above 0.2°K, is proposed for an international standard. This relation is expressed by an equation which represents the vapor pressure ($P_3$) of liquid $He^3$ from 0.2°K to the critical temperature (3.324°K): $\ln P_3 = 2.24846 \ln T - 2.49174/T + 4.80386 - 0.286001\ T + 0.198608\ T^2 - 0.0502237\ T^3 + 0.00505486\ T^4$. The physical basis for this equation is discussed. It is proposed to join the $He^3$ and $He^4$ International Vapor Pressure Scales at 2.2450°K which is a little above the λ-point temperature of $He^4$. (M.C.G.)

**31352** (TID-3568(Rev.1)) CRITICAL PATH SCHEDULING. A Preliminary Literature Search. Hugh E. Voress, Elmer A. Houser, Jr., and Fred E. Marsh, Jr., comps. (Division of Technical Information Extension, AEC). July 1962. 34p.

Results of a literature survey on critical path scheduling are presented. Other names which were used to identify this planning technique include PERT, PEP, and LESS. A total of 305 references are included. (J.R.D.)

**31353** LONG-TERM ENERGY REQUIREMENTS AND ATOMIC ENERGY. M. P. Ailleret. Bull. soc. franç. electriciens, (8), 2: 7p.(Nov. 1961). (In French)

In a consideration of the long term energy needs, the exponential expansion of energy requirements and the uncertainties in the supply of conventional fuels are first considered. The hopes in the realm of energy with respect to economy and possible expanded output are then discussed. The cost of nuclear energy and the possible shortage of uranium are reviewed. (J.S.R.)

**31354** FLUCTUATIONS OF GROUND-WATER LEVELS DUE TO ATOMSPHERIC PRESSURE CHANGES FROM NUCLEAR EXPLOSIONS. J. Ineson (Geological Survey, London). Nature, 195: 1082-3(Sept. 15, 1962).

Hydrographs from wells sunk into aquifers in southern England showed rapid responses of the water levels to atmospheric pressure changes from the Russian nuclear explosions of Oct. 23 to 30, 1961. The fluctuations were on the order of 0.01 to 0.02 ft. Successive reflexions of the pressure waves were also found to affect the water levels. The mechanism of the water-level fluctuations is discussed. A large fluctuation of 0.045 ft was recorded on August 5, 1962, after the Russian explosion. (D.L.C.)

**31355** EURATOM'S ACTIVITIES AND FUTURE AIMS. Curt Heidenreich (Euratom Office, Washington, D. C.). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 9p. $0.50.

The activities of EURATOM are carried out through four Common Research Centers (at Ispra, Italy; Petten, Netherlands; Geel, Belgium; and Karlsruhe, Germany) and through research contracts, contracts of association, and a power reactor participation plan. It is expected that 95% of the initial 5-year program will be fulfilled by the end of this year. General aspects and objectives of the second 5-year program are discussed briefly. (A.G.W.)

**31356** FUTURE USE OF URANIUM. Stephen B. Roman (Denison Mines Ltd., Can.). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 15p. $0.50.

The largest single use for U in the future is expected to be in the field of nuclear power. The rate of increase of the world's power needs and the rate of consumption of fossil fuel supplies necessitate further development of nuclear power reactors. Costs of nuclear power are approaching the competitive range and further reductions can be foreseen. (A.G.W.)

**31357** FRIEDLICHE NUTZUNG DER KERNENERGIE. IHRE VORTEILE UND IHRE GEFAHREN. (Peaceful Uses of Nuclear Energy. Its Advantages and Dangers). L. v.

Eriehsen, ed. Berlin, Gottingen, Heidelberg, Springer-Verlag, 1962. 235p.

Problems in the peaceful uses of nuclear energy are discussed. The characteristics of nuclear energy are compared with energy produced by classical methods, and its advantages and dangers are outlined. Topics covered include: principles, methods, and physical-technical details of nuclear energy uses; instruments and construction equipment for nuclear power plants; damaging radiations from reactions in power reactors; raw materials for nuclear fuel; finishing worked nuclear fuels; radioactive fallout from nuclear energy production; sites and safety; sociological aspects of nuclear energy uses; scientific aspects of nuclear energy uses; and uses and dangers of nuclear energy. (M.C.G.)

**31358** THE CANADIAN NUCLEAR ASSOCIATION AND NUCLEAR POWER. J. Lorne Gray (Atomic Energy of Canada Ltd., Ottawa). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 9p. $0.50.

The respective roles of Atomic Energy of Canada Ltd. (AECL) and the Canadian Nuclear Association in development of nuclear power in Canada are discussed. Research and development work currently being done by AECL and research facilities available to industry are reviewed. (A.G.W.)

**31359** THE ROLE OF I.A.E.A. IN THE DEVELOPMENT OF NUCLEAR POWER. Pierre L. Balligand (International Atomic Energy Agency, Vienna). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 5p. $0.50.

The overall nuclear power programs of various countries are reviewed. Things the agency can do to assist its member states are discussed. (A.G.W.)

**31360** INTERNATIONAL COOPERATION IN ATOMIC ENERGY. Gunnar Randers (Institutt for Atomenergi, [Kjeller], Norway). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 5p. $0.50.

International cooperation in atomic energy started in the hope that one might control further spread of atomic weapons by controlling peaceful uses in those nations that did not have them. Effective controls were found to be impossible to establish. Today international cooperation is based on economic and industrial considerations; this means picking out those nations and those firms which work in the same field and with whom cooperation would be profitable. (A.G.W.)

**31361** ON PAKISTAN'S APPROACH TO NUCLEAR POWER. Mohammed Nasim (Pakistan Atomic Energy Commission, Pakistan). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 18p. $0.50.

Pakistan's existing power resources and predicted future power demands are reviewed. Cost estimates for both nuclear and conventional power plants are given. It is concluded that generation of electrical energy by nuclear plants in Pakistan is economically feasible if high load factors are available to operate the plant. (A.G.W.)

**31362** REACTIVITY OF SOLIDS. Proceedings of the 4th International Symposium, Amsterdam, May 30-June 4, 1960. J. H. De Boer, ed. Amsterdam, Elsevier Publishing Co., 1961. 770p.

Proceedings of the Fourth International Symposium on the Reactivity of Solids are presented. Eighty papers are included on the following topics: mechanism and kinetics of reactions of solids, factors influencing reactivity, reactivity studies with technical implication, and methods of investigation. Subject and author indexes are given. Separate abstracts were prepared for 18 papers. Five papers were previously abstracted for NSA. (M.C.G.)

**31363** ISOTOPE EFFECTS IN DIFFUSION. A. B. Lidiard (Univ. of Reading, Eng.). p.52-6 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

Theoretical expressions for the diffusion coefficients of atoms in crystals contain a factor which represents the feature of some mechanisms (vacancy, interstitialcy) that successive jumps of an atom are correlated with one another. This factor depends on the mechanism, the geometry of the lattice, and certain relative jump frequencies (e.g., ratio of solute–vacancy exchange rate to solvent–vacancy exchange rate in the case of impurity diffusion). The determination of this correlation factor in isolation from the other terms in the diffusion coefficient is one direct way of obtaining information about diffusion mechanisms. In ionic-conductors this was done by studying both ionic conductivity and self-diffusion. Schoen recently pointed to a method, in principle applicable to all classes of solids, which is based on the fact that isotopic effects in diffusion are proportional to the correlation factor for the appropriate mechanism. This method is based also on the assumption that the individual jump frequencies are dependent on isotopic mass M as $M^{-1/2}$. It is shown how measurements of isotope effects in diffusion experiments made on ionic crystals in the presence of a steady electric field enable this mass dependence to be verified. Existing data for Na in NaCl confirm the $M^{-1/2}$ dependence but it is important that these measurements be extended to other systems. Similar experiments on the relative rates of diffusion of $Li^6$ and $Li^7$ in Ge would be equally valuable. (auth)

**31364** THE SINTERING OF PURE AND "DOPED" METAL OXIDES. P. E. D. Morgan and A. J. E. Welch (Imperial Coll. of Science and Tech., London). p.105-11 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

The isothermal shrinkage of metal-oxide compacts at temperatures up to 1400°C was measured by means of a dilatometer, with which linear dimensional changes could be continuously observed. The pure oxides studied, selected in order to bring out the broad effects of crystal structure and to avoid undue complexities due to non-stoichiometry, were MgO, $Al_2O_3$, $SnO_2$, $TiO_2$, and $Nb_2O_5$. The linear shrinkage of each of the pure oxides, over a wide range of porosity, is given by the expression $dL/dt = -k/t$, where L represents the length of the compact, t is time at the shrinkage temperature, and k is a rate constant. The variation of k with temperature T follows an exponential expression of the usual type, $k = k_0 \exp(-E/RT)$, in which E is an activation energy. At the lower temperatures (where k is small), the observed k value is constant over very long periods of shrinkage (e.g., from t = 2 min up to several days), but at higher temperatures there is evidence of a sudden decrease in k after the very early stages of shrinkage; this appears to coincide with onset of rapid recrystallization. MgO, $Al_2O_3$, $TiO_2$, and $Nb_2O_5$ showed appreciable crystal growth only after shrinkage to high bulk densities; $SnO_2$, possibly on account of its volatility, crystallized at low bulk densities. Crystallization and other textural changes were observed by x-ray measurements of crystal size, and by microscopical examination. The rate of heating from ambient temperature to the temperature of shrinkage was found to affect the subsequent isothermal shrinkage behavior, particularly in the case of $SnO_2$. Some corresponding measurements on MgO "doped" with impurities, particularly $TiO_2$ and $Fe_2O_3$, are briefly reported. (auth)

**31365** POLYMERIZATION OF VINYL COMPOUNDS IN THE CRYSTALLINE STATE. H. Morawetz (Polytechnic

Inst. of Brooklyn). p.144-53 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

When crystalline vinyl derivatives such as acrylamide, acrylic acid salts, and vinyl stearate are exposed to ionizing radiation at −78°C, radicals are introduced into the crystal lattice which may subsequently initiate a polymerization in the solid state when the crystals are thermostated at temperatures well below their melting points. In the case of acrylamide, radical concentrations estimated from electron spin resonance are in good agreement with the number of polymer chains obtained from polymer yield and molecular weight date, indicating that all of the radicals initiate chains and that chain transfer is negligible. Although the radical concentrations remain almost constant, the polymerization rate decays rapidly; however, it does not come to a complete stop even after several months. Polymer yields of 40% and molecular weights of $1.5 \cdot 10^6$ may be attained. The rate of growth of the individual chains is independent of their number. Initial rates increase somewhat less rapidly than the irradiation dose, indicating that at high doses most of the radicals recombine before initiating a chain reaction. In solid solutions of acrylamide with the isomorphous propionamide the rate of monomer conversion to polymer is independent of the propionamide concentration up to 50% of the saturated compound. However, the propionamide causes considerable chain transfer, so that the molecular weight of the product is reduced and becomes almost independent of conversion. The chain transfer efficiency of propionamide decreases with rising temperature. With alkali salts of acrylic acid, the potassium salt is much more reactive than the Li and Na salts, which can only be polymerized at much higher temperatures. The chain lengths of polymers obtained from these salts is time independent, indicating extensive chain transfer to monomer. The molecular weights of the polymers are about 200,000 for potassium acrylate polymerized at 0 to 35° and 20,000 for sodium or lithium acrylate polymerized at 120 to 150°. Control of the polymerization process by the crystal lattice is indicated by: large differences in the solid state polymerizability of monomers, which are unrelated to their reactivity in the liquid state or their radiation sensitivity; the widely different behavior of different acrylic acid salts, although the polymerizing species is the acrylate ion in all these cases; and the high chain transfer efficiency of propionamide in acrylamide polymerization and particularly the negative temperature coefficient of the chain transfer efficiency which is contrary to the behavior of chain transfer agents in the liquid state. The characteristics of the acrylamide lattice would not be expected to favor stereoregulated polymerization, but this might be possible with other crystalline monomers. (auth)

**31366** KINETIC STUDY OF THE HYDRIDATION OF LANTHANIDES. R. Viallard (Faculté des Sciences, Paris). p.168-77 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In French)

Many studies concerning lanthanide hydrides were made after Winkler (1891) observed that lanthanum and cerium absorb hydrogen, and Matignon (1900) showed that these metals, as well as praseodymium, neodymium, and samarium, combine directly with hydrogen. The nature of the products could be elucidated to a large extent, and some of their characteristics were given. The interstitial nature of compounds of this type, assumed by Hägg as early as 1931, was definitely settled when crystallographic studies, following the early work of Rossi (1934), led first to the determination of the lattice sites of the atoms of the heavy element (lanthanum: Dreyfus-Alain and Viallard, 1953, Dreyfus-Alain, 1954; lanthanum, cerium, praseodymium, neodymium, samarium: Holley, Mulford, Ellinger, Koehler and Zachariasen, 1955; gadolinium: Sturdy and Mulford, 1956; etc.) and later on to the localization of the hydrogen atoms in interstitial sites of the lattice (Holley, Mulford, Ellinger, Koehler and Zachariasen, 1955). Furthermore, studies by Sieverts and Gotta (1928) showed that the hydrogenation of rare earth metals is strongly exothermic, and Diller and Rothe more recently (1955) were able to show that, of the three hydrogen atoms per metal atom that were fixed by cerium, the first two are ten times more firmly bound than the third one. As regards kinetics, the hydrogenation of rare earth metals exhibits some peculiar aspects. Matignon (1900) discovered that hydrogen combines rapidly with freshly prepared metal, but Sieverts and Muller-Goldegg (1923) observed that secondary factors could in fact govern the course of the reaction when metal in bulk or in filings was used. Mikheeva and Kost (1958) showed that the cleanliness of the surface is of upmost importance for the uptake of hydrogen by cerium. It appears that in every case a mechanism is operative similar to that involved in diffusion of hydrogen in other transition metals. This implies, according to an assumption Ramsay set forth as early as 1894 for the diffusion of hydrogen in palladium, a dissociation of hydrogen molecules into atoms. A direct argument in favor of the occurrence of such a dissociation process was given, when it was shown that isotopic hydrogen exchange reactions with cerium hydride or deuteride involve the production of HD from molecular $D_2$ or $H_2$ (Viallard, 1945). If Pilling and Bedworth's rule were applicable to such solid-gas systems, the rate of penetration of hydrogen into the solid should obey a parabolic law, provided V hydride/V metal $\gtrsim$ I (V = lattice volume of respective species). In fact, the curve is generally a sigmoid, whether the reaction is rapid or slow. This demonstrates the complexity of the phenomenon. An over-all picture is given, with the aim of providing a better understanding of this problem on the basis of physico-chemical, structural, and textural information. The assumptions involved are discussed. (auth)

**31367** TRITIUM EXCHANGE BETWEEN WATER AND THE HYDROXIDES $Ni(OH)_2$ AND $\alpha$-FeOOH. W. Feitknecht, A. Wyttenbach, and W. Buser (Universität, Bern). p.234-9 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

It was shown previously that the first step of the oxidation of the hydroxides of some transition metals may be explained by assuming that $H^+$ and electrons diffuse through the crystals to the surface. In order to verify the assumption of a high diffusion coefficient of $H^+$ in the hydroxide lattice, the rate of exchange of tritiated hydroxides with $H_2O$ was measured. The average diameter of the crystals was obtained from electron microphotographs, and the surface measured by the BET-method. In all experiments the ratio between the number of H-atoms in the hydroxide to that in the water was very small (~0.01 to 0.003). The exchange in liquid water was performed in small tubes, one tube for every point of the exchange curve. For the exchange in water vapor (~0.9 At.) the hydroxide was shaken in a glass container and samples of the vapor taken out from time to time. In all experiments a rapid exchange, interpreted as surface exchange, was followed by a slower reaction, due to self-diffusion. The surface exchange of $Ni(OH)_2$, taken per $cm^2$ was much less for a sample with larger crystals (prepared at 200°) than for smaller crystals (prepared at 60°), which was probably due to differences in the perfection of the surface. FeOOH showed a 2 to 3 times smaller surface exchange than $Ni(OH)_2$ of comparable surface. In liquid water the slow exchange of $Ni(OH)_2$ was ir-

regular, which was probably due to recrystallization. For the exchange of $Ni(OH)_2$ in vapor the slow exchange (after correction for the surface exchange) plotted against $t^{-\frac{1}{2}}$ gave a straight line up to an exchange of ~0.6. This was in agreement with the theory of diffusion in sheets. The temperature dependence of the self-diffusion follows the Arrhenius equation, leading to an activation energy of ~23 kcal for $Ni(OH)_2$ (between 100 to 160°) and ~165 kcal for $\alpha$-FeOOH (between 50 to 174°). (auth)

**31368** IRRADIATION OF COMPOUNDS IN THE SOLID STATE. M. Camp, S. K. Deb, B. L. Evans, H. M. Montagu-Pollock, and A. D. Yoffe (Cambridge Univ., Eng.). p.321-33 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

The photolysis of solid thallous azide, mercurous azide, and triphenylmethylazide and the decomposition in an electron beam of solid silver azide and silver cyanamide were studied. The electron energy levels of solid thallous azide were estimated from the optical absorption spectrum at low temperatures and from photoconduction above −60°C. Above room temperature its rate of photochemical decomposition was measured as a function of temperature, light intensity, and wavelength. The activation energy was found to possess one or two values depending on the wavelength. The decomposition of this ionic azide apparently develops by an electron transfer mechanism $N_3^- \rightarrow N_3 + (e)$ and $2N_3 \rightarrow 3N_2$. Mercurous azide and triphenylmethylazide are largely covalent and it is suggested that here the photodecomposition begins by fission of the longest nitrogen-nitrogen bond. Decomposition by high-intensity beams of the silver compounds is characterized by the formation of abundant small nuclei of silver which are ordered with respect to the parent azide lattice, indicating that the mechanism differs from that of thermal decomposition. Low intensity beams have a similar effect to that of heat. (auth)

**31369** THE EFFECT OF FISSION FRAGMENT AND NEUTRON IRRADIATION ON THE KINETICS OF ZIRCONIUM OXIDATION. B. Cox (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.425-35 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

American work showed previously that zirconium alloys undergo severely accelerated oxidation as a result of bombardment by fission fragments in solution at high temperature. The mechanism of this enhanced attack was investigated by several parallel approaches. First, kinetic studies were carried out at sufficiently low fission power densities to span the transition from the normal un-irradiated oxidation behavior to that characteristic of oxidation at the higher power densities. Second, a study was made of the transformation from monoclinic to cubic phase which occurs in $ZrO_2$ under irradiation by either fast neutrons or fission fragments. A transformation of this type in the protective oxide film was postulated previously as a possible cause of the enhanced oxidation rate. Third, the effect of irradiation on the solution rate of $ZrO_2$ was examined, as this represented a further mechanism by which enhanced attack could proceed. Results showed that the phase transformation does not occur with sufficient rapidity to play a significant part in the enhanced oxidation. It was also shown that the transformation is very dependent on the presence of possible nuclei of the cubic phase in the initial material. No increased solution rate was observed which was of sufficient magnitude to explain the previous kinetic results. The kinetic data, which were obtained at low fission power density, showed that the increased oxidation rate results from an increase of the initial diffusion controlled oxidation of the zirconium alloy. The initial oxidation rate increased with increasing damage rate from fission fragment irradiation. It is suggested that the fission fragment tracks, which do not anneal completely at the temperatures employed (300°C), provide easy diffusion paths through the oxide film and thereby increase the transport of reactive species up to the metal/oxide interface. This mechanism can be correlated with ideas on the mechanism of diffusion through the oxide film in the absence of irradiation. (auth)

**31370** THERMAL ANNEALING OF DAMAGE PRODUCED BY THE 2.0 Mev ELECTRON IRRADIATION OF TYPE IIa DIAMOND. C. D. Clark and D. W. Palmer (Univ. of Reading, Eng.). p.436-45 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

Diamonds which were colored by 2-Mev electron irradiation were heated at temperatures between 200 and 800°C. The changes in the absorption spectra resulting from each treatment were measured. Many reactions were observed, but because the various defects contributing to these gave absorption in different spectral regions it was possible to follow the rates of reaction for many of the processes reasonably independently. Activation energy spectra for the annealing and orders of reaction for some of the processes were determined. (auth)

**31371** EFFECTS OF HIGH ENERGY RADIATION AT THE SURFACE OF SOLIDS. N. Riehl, W. Marth, and R. Sizmann (Technische Hochschule, Munich). p.446-51 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

Experiments were carried out dealing with radiation effects at the surface of metals due to high energy particles. Alpha particles ($Po^{210}$), heavy recoil atoms (ThC), and neutrons from the Munich swimming pool reactor were used. The purpose of the work was to contribute to research on the general problem of radiation damage in solids. It was expected that some additional information on primary and secondary effects of radiation would be obtainable if the radiation effects occur at the surface of the solid, so that direct observations can be carried out by optical, electron optical, and other suitable methods. In some cases these surface effects may then allow conclusions on the nature of the bulk effects. (auth)

**31372** THE HIGH-TEMPERATURE SOLID-STATE REACTIVITY OF CERAMIC NUCLEAR FUELS. R. Lindner (Chalmers Univ. of Tech., Gothenburg, Sweden). p.467-74 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

$UO_2$ and UC are used as fuel and $ThO_2$ as breeding material in nuclear reactors. The diffusion of fission products, especially gases, may limit the use at high temperatures, self-diffusion may determine the mechanical behavior (plastic flow, sintering). The diffusion constants were measured for the fission products $Kr^{85}$ and $Xe^{133}$ in "$UO_2$" with varying oxygen excess and in $U_3O_8$, and for $Xe^{125}$ in UC and $ThO_2$. In addition, the diffusion of $Rn^{222}$ in $UO_2$, $U_3O_8$, and $ThO_2$ was investigated to obtain a general view on noble gas diffusion and its dependence on the size of the diffusing atom. Self-diffusion of $U^{233}$ in $UO_2$ was, according to preliminary results, shown to proceed with an activation energy of about 110 kcal·mole$^{-1}$ or less in approximate accordance with the temperature function of plastic flow. (auth)

**31373** EFFECT OF PROTON IRRADIATION UPON CATALYTIC ACTIVITY. Aija Spilners and R. Smoluchowski (Carnegie Inst. of Tech., Pittsburgh). p.475-8 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

An influence of high-energy proton irradiation on electrode potential, on solubility, and on reduction of solids was observed. A study was made of similar effects in the decomposition of formic acid into carbon dioxide and hydrogen in the presence of metallic copper and the ensuing rise in pressure. The reaction, which is of zeroth order, was studied isothermally in the temperature range from 150 to 185°C and the rate constants and the activation energies were determined. The sample was in form of a sheet of an area of 100 to 200 $cm^2$. It appears that an irradiation with a 350 Mev proton flux of the order of $10^{15}$ lowers the activation energy from about 25 kcal to half this value. In order to distinguish between the various models of this unusual behavior, measurements of catalytic activity of electrolytically polished copper were made. It appears that in this case too the reaction rate and the activation energy are low. It is suggested then that the influence of proton irradiation can be interpreted as a result of accelerated diffusion, in particular, surface diffusion. This increased surface mobility eliminates surface sites introduced by pre-activation, which are presumably strain free, and leaves only those which are more stable, such as strained regions surrounding a dislocation emerging at the surface. A quantitative estimate is made. (auth)

**31374** EFFECT OF RADIATION ON RATE PROCESSES IN ALLOYS. A. C. Damask (Brookhaven National Lab., Upton, N. Y.). p.479-88 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (BNL-4663). (In English)

The interchange of atoms in a large class of metals and alloys takes place by the vacancy mechanism. Excess vacancies introduced by irradiation therefore enhance the diffusion rate. The severe local damage associated with neutron irradiation can break up regions of ordered or precipitated atoms and nucleate new phases, but electron and gamma irradiation can only accelerate diffusion during irradiation at temperatures where the vacancies are mobile. The effects of these types of irradiation on alloys are discussed and neutron irradiation data on typical short-range ordering, long-range ordering, precipitating, and clustering alloys are reviewed. The enhanced diffusion phenomenon was isolated and treated separately. It is shown that the flux and temperature behavior of diffusion enhancement is strongly dependent on whether the excess vacancies are removed by migration to fixed sinks, recombination with interstitials, or both. Experiments on $\alpha$-brass show that its short-range order is neither nucleated nor destroyed by neutron irradiation, and therefore the enhanced diffusion process alone is experimentally accessible. The results of reactor irradiation of $\alpha$-brass confirm the theory and show that the vacancies are removed by migration to fixed sinks, and that recombination with interstitials is negligible. Field experiments in the vicinity of a test nuclear rocket engine permitted arrangements in which the flux could be varied with no absorbing medium other than air. Thus, the energy spectrum of neutrons remained constant. These experiments confirmed the flux dependence of enhanced diffusion. Further experiments using gamma rays indicated a different mechanism of vacancy removal, probably because a large amount of interstitial-vacancy recombination can take place. The relative efficiencies of neutron, electron, and gamma irradiation for diffusion enhancement are shown. Because of the deleterious effects neutrons are not a reliable method for enhancing diffusion in other than short-range ordering alloys. Available gamma sources require too much time to produce an appreciable effect. Although the penetration depth of electrons from an accelerator is limited, it is shown that production of low temperature equilibrium states of alloys can be successfully achieved on laboratory-size samples. An example is shown in which $\alpha$-brass is brought to its minimum free energy state at 50°C in a few hours irradiation: a state which would require 30,000 years to produce by thermal means. Some applications of this technique are discussed. (auth)

**31375** REACTIVITY PROBLEMS CONCERNING THE FORMATION OF CERAMIC MATERIALS. F. J. P. Clarke and J. Williams (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.593-601 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

Some reactivity problems concerning the formation of ceramic materials are reviewed especially with reference to particular demands for nuclear ceramics. (auth)

**31376** REACTIONS BETWEEN DIFFERENT TYPES OF GLASS AND OXIDES OF EARTH METALS. J. A. Hedvall (Silikatinstitut, Göteborg). p.622-6 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

Even in the solid state the reactivity and the recrystallization capacity of the various silica modifications largely depend on their pretreatment and storage in different gas atmospheres. Changes in the adsorption capacity depend on the same factors. Experiments with glass capillaries, where recrystallization effects are out of the question, proved that changes in the structure in the transition range exerted a strong effect in the case of glass that was pretreated in various gases or in vacuo. Only the capillaries pretreated in oxygen showed no such effect. Reactivity experiments were carried out on powder mixtures of various types of glass with strontium oxide, calcium oxide, and magnesium oxide. The reactivity of glass samples containing water was compared with that of samples which had been dehydrated in vacuo. Reaction occurred in all cases. The dehydrated samples were without exception less reactive than those containing water. Particularly in the case of the latter preparations, such large reaction yields were attained that the glass structure was destroyed. The complexity of the reaction mechanisms is stressed and the part played by the considerable change of the surface by the reactions is discussed. A decided influence of changes of the structure in the transition range on the reactivity was demonstrated in some cases, where the glass itself reacted and no crystallization or other processes in the surface layer interfered with the reactions. (auth)

**31377** EFFECT OF LATTICE DEFECTS ON THE REACTIVITY OF GRAPHITE. Gerhart R. Hennig and Manuel A. Kanter (Argonne National Lab., Ill.). p.649-60 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

Three types of lattice defects were found to increase the chemical reactivity with oxygen of graphite single crystals. These are screw dislocations, Frenkel defects, and quenched-in defects. No increased reactivity except under special conditions of oxidation was associated with twin boundaries and low angle boundaries. The morphology and reactivity of the various defects were studied by optical and electron microscopy and by kinetic measurements. Screw dislocations of large Burgers vector were identified in most single crystals of natural graphite. Their size and extent within the crystals were determined by examination of new surfaces exposed after repeatedly cleaving the crystals. Spiral markings which were present on the original surfaces of occasional crystals were always centered on such screw dislocations. However, screw dislocations were also found in most other crystals free of spiral surface markings. Near such dislocations, the oxidation rate

was excessively high resulting in pit formation. Frenkel defects produced by neutron irradiation caused a pronounced increase in oxidation rate. They were found to facilitate oxidation of the normally unreactive basal surfaces causing formation of minute irregularities or pits. This pitting could be enhanced by metallic catalysts which normally do not produce such pits in unirradiated graphite. Such catalytic pitting was also observed with crystals in which Frenkel defects had been produced by irradiation with 1-Mev electrons. Quenching of crystals from temperatures above 2300° introduced defects which increased the subsequent reactivity to oxygen in the presence of catalysts. Pronounced pits similar to those in electron irradiated crystals were formed. Preliminary kinetic studies of the formation and decay of these defects were made. It is believed that the excess reactivity which results in the formation of catalytic pits in irradiated or in unirradiated or in quenched crystals is due to the presence of lattice vacancies. (auth)

**31378** OBSERVATION OF RADIATION DAMAGE WITH THE FIELD ION MICROSCOPE. Erwin M. Mueller (Pennsylvania State Univ., University Park). p.682-91 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In English)

In the field ion microscope individual vacancies can be seen and their density determined by controlled field evaporation and examination of each net plane appearing at the surface. Interstitials just below the surface as they are intrinsically present as imperfections, or as they are introduced by diffusion, appear clearly in the form of bright spots when they bulge out a surface net plane. The intersection with the surface of single dislocations or more complex imperfections are easily recognized in otherwise perfect metal crystals. The production of all those defects by irradiation can be observed instantaneously if the microscope is connected with a radiation source. While the specimen is kept at liquid hydrogen temperature, undesired annealing of point defects is prevented. The first experiments were made with a one millicurie 5.4-Mev $\alpha$ source. On the average one impact event was seen every 20 minutes, e.g., all hits on the $10^{-10}$ $cm^2$ specimen area under observation in one million times magnification were recorded. The tip diameter of between 500 and 2000 Å was small compared to the $\alpha$ range in the W or Pt specimen. On the exit side of the track there appeared suddenly a region of about 50 Å diameter containing some 15 to 30 vacancies and interstitials. There are also one or two places elsewhere on the tip surface where up to 3 clustered interstitials are created simultaneously, sometimes as far away from the exit of the displacement spike as half a tip radius. This may be the result of the interaction of a focuson with the surface. When the irradiation was extended to over one week with the specimen at 77°K, the integrated damage by the impact of some 500 $\alpha$ particles was not very extensive. In order to study the more effective low energy end of the track irradiation was also done with well collimated 20-kev neutral helium atoms. These were obtained by charge exchange with a helium ion beam extracted from a Penning discharge. Because of the limited range of these particles tip radii below 500 Å were used. The beam density of neutrals was about $10^{10}$ $sec^{-1}$ $cm^{-2}$, of which only one hundredth produced damage visible at the surface. Now there appears one interstitial at the entrance side, while at the exit side a cluster of 3 to 5 interstitials in a region of 25 Å diameter marks the displacement spike. The greatest damage to the lattice was caused by bombardment of the surface with ions of a few hundred ev energy in normal incidence. At ion current densities of $10^{-2}$ $A/cm^2$ the initial perfection of the lattice is destroyed within a few seconds, and complex dislocations appear. These can be rearranged, but not completely removed, by the stress connected with field evaporation. (auth)

**31379** STUDY OF THE EVOLUTION OF CRYSTAL STRUCTURE OF URANIUM BY NEUTRON CRYSTALLOGRAPHY. J. Laniesse, M. Englander, and P. Meriel (Centre d'Études Nucléaires, Saclay, France). p.700-8 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In French)

The method described has the advantage over the classical x-ray-diffraction method of giving fuller and quicker information about the texture of a bulk polycrystalline aggregate of uranium metal, and of following more easily the evolution of its crystalline structure during the allotropic transformation. The method uses a thermal neutron beam from the Saclay C.E.N. Reactor EL. 3, monochromatized at $\lambda = 1.143$ Å $\pm$ 0.030 Å, and after collimation directed at an optimal-dimensioned cylindrical specimen, perpendicularly to the axis. The scattered neutron beam passes through a $BF_3$ counter which can describe a circle of 130 cm radius centered on the specimen, in the horizontal plane containing the neutron beam axis. The specimen is entirely free from residual or parasite texture. The reference diffraction lines of the pure $\alpha$-phase uranium are determined at room temperature by means of a recording meter and a counting device. The same method gives the diffraction patterns of the $\beta$-phase uranium by using, instead of pure uranium, a metastable solid solution containing a minimum concentration of some metallic impurities (Cr or Si). These patterns are then compared with the calculated ones and the x-ray-diffraction patterns. After choosing a certain number of given diffraction lines, it was possible to examine qualitatively and semi-quantitatively the evolution of possible predominant orientations with mechanical and/or thermal treatments. By following the intensity of a "mixed" diffraction line suitably placed within the lines of the $\alpha$ and $\beta$ spectra, it was possible to determine the kinetics of the $\beta \rightarrow \alpha$ transformation at temperatures where frequency and counting rates are adequate. By way of examples, results obtained with a 600°C extruded pure U rod (reduction in area = 10.4), and with a four times $\beta$-water quenched $\alpha$ extruded specimen are illustrated. It also shows the equation giving the time for the $\beta \rightarrow \alpha$ transformation at 333°K of a bulk U alloy containing 1000 ppm chromium. (auth)

**31380** EFFECTS OF NEUTRON IRRADIATION ON PURE IRON AND Fe–Ni ALLOY (50%-50%). D. Dautreppe, J. Paulevé, P. Moser, and P. Brisconneau (Centre d'Études Nucléaires, Grenoble, France). p.735-42 of "Reactivity of Solids." Amsterdam, Elsevier Publishing Co., 1961. (In French)

Measurements of magnetic after-effect and anisotropy are very sensitive to defects induced by neutron bombardment, and are very interesting methods for the study of these effects. After neutron irradiation of a sample of Johnson-Matthey pure iron, a zone of magnetic after-effect was found covering the range 20 to 100°C. The activation energy of the defects, determined by measuring the relaxation time as a function of temperature is 1.2 ev. Resistivity measurements show that about 40% of the defects remaining at room temperature are responsible for the magnetic after-effect. Neutron irradiation at 80°K was performed on a pure iron sample. Three zones of magnetic after-effect were found. The first one at 110°K is the most important, the activation energy of the defects is about 0.3 to

0.4 ev. This value is consistent with the motion of interstitials. Irradiation with neutrons, at room temperature in the presence of a saturating magnetic field of 2500 oersteds, performed on Fe–Ni (50%–50%) samples gave a uniaxial anisotropy in the samples. These results confirm the experiments of Schindler and Salkovitz in which the anisotropy was detected by the observation of hysteresis loops. (auth)

# BIOLOGY AND MEDICINE

## General and Miscellaneous

**31381** (ANL-6535) BIOLOGICAL AND MEDICAL RESEARCH DIVISION SEMIANNUAL REPORT JULY THROUGH DECEMBER 1961. (Argonne National Lab., Ill.). Apr. 1962. Contract W-31-109-eng-38. 169p.

Thirty-seven articles are included; separate abstracts were prepared for 24. Two articles on the effects of radiation on methionine sulfonium compounds and on silica gel structure and the chromatographic process were previously abstracted in NSA. The articles not abstracted include information on life span and fertility of irradiated mice, biochemical studies on Cu(I,II)-peroxy theory of radiobiological effects and their modification, studies on the giant amoeba, low temperature storage of epoxy resins used for embedding in electron microscopy, method for obtaining fixing solutions osmotically equivalent to physiological saline solution, and $P^{32}$ uptake as an indicator of tritiated thymidine toxicity. (P.C.H.)

**31382** (ANL-6535(p.5-12)) PROGRESS REPORT: X- AND GAMMA-RAY TOXICITY. Douglas Grahn, Katherine F. Hamilton, and George A. Sacher (Argonne National Lab., Ill.).

Three inbred mouse strains and one hybrid were exposed to gamma radiation at age 100 days. The BALB/c strain showed considerable improvement in survival. Changes found in animal husbandry procedures reduced infection pressure and improved the quality of the animals. The three longest-lived strains, BC $F_1$, C57BL/6, and BALB/c, all demonstrated a measurable degree of life-shortening down to the very lowest dose levels. A lack of response of the A/Jax strain mice at doses below 12 r/day was attributed to a mechanism entirely different from one of infectious disease pressure. Sex difference in life shortening was predominant in the effects of whole-body sublethal x irradiation. Among the males, life-shortening at 100 r was generally small or nonexistent and consistently below that at the 0.6 $LD_{50/30}$ dose. Discussion is also given on the genetics of radioresistance. (P.C.H.)

**31383** (ANL-6535(p.13-14)) SURVIVAL OF GUINEA PIGS GIVEN PERIODIC GAMMA-RAY EXPOSURE FOR THE DURATION OF LIFE. George A. Sacher, Douglas Grahn, and Robert J. Robertson (Argonne National Lab., Ill.).

Results on the survival of guinea pigs exposed to gamma radiation at five exposure levels, ranging from 1.35 to 36 r/week, for the duration of life are reported. The higher levels of exposure, 24 and 36 r/week, were extremely lethal. No evidence was found that 1.35 or 5.4 r/week produce excess mortality. (P.C.H.)

**31384** (ANL-6535(p.15-16)) THE LIFE SPAN OF THE CHICKEN. S. Phyllis Stearner and Emily J. Christian (Argonne National Lab., Ill.).

Results on the survival of White Leghorn chickens irradiated over a period of 6 years (2190 days) are given. There was a high juvenile mortality, but throughout the adult period up to 200 days the survival curve approximates an arithmetic straight line. A 50% survival existed at 2050 days. After 2000 days, there was indication of an increase in mortality. Mortality is largely associated with lymphomatosis. (P.C.H.)

**31385** (ANL-6535(p.17-18)) USE OF AMMONIUM THIOCYANATE TO INCREASE THE SENSITIVITY OF THE FERROUS SULFATE DOSIMETER. Norman A. Frigerio (Argonne National Lab., Ill.).

The addition of ammonium thiocyanate ($NH_4SCN$) to an exposed ferrous sulfate dosimeter was found to increase the spectrophotometric sensitivity by a factor of 6. The increased sensitivity resulted from the increased extinction coefficient of the ferric thiocyanate complex [$Fe(SCN)_6^{3-}$, $\epsilon_{475}$ = 17600 liters/mole cm] compared to that of ferric ion alone ($Fe^{3+}$, $\epsilon_{304}$ = 2187 liters/mole cm). (P.C.H.)

**31386** (ANL-6535(p.19-20)) COMPARATIVE PROTECTIVE VALUE OF AET-THIOGEL A IN GAMMA-IRRADIATED AND NEUTRON-IRRADIATED MICE. Donn L. Jordan and Howard H. Vogel, Jr. (Argonne National Lab., Ill.).

Mice were irradiated with single doses of fission neutrons and $Co^{60}$ gamma rays in the acute lethal range. The experimental animals then received 1 ml of solution containing 8.5 mg AET and 100 mg Thiogel A by oral injection. Half the injection was given approximately 20 minutes before and the other half immediately before irradiation. Dose reductions of 19 and 9% were found for gamma radiation and fission neutrons, respectively. (P.C.H.)

**31387** (ANL-6535(p.22-5)) PROGRESS REPORT: MAMMARY TUMOR INCIDENCE AND LONGEVITY IN FEMALE SPRAGUE-DRAWLEY RATS IRRADIATED WITH FISSION NEUTRONS OR $Co^{60}$ GAMMA RAYS (600 DAYS AFTER FIRST IRRADIATION). Howard H. Vogel, Jr. and Donn L. Jordan (Argonne National Lab., Ill.).

Comparisons were made on the incidence of mammary tumors in rats given four whole-body exposures at weekly intervals to either 100 rads of fission neutrons or 200 rads of $Co^{60}$ gamma rays. Approximately 90% of the rats developed mammary tumors within 20 months of the first exposure. Fission neutrons were found to be at least twice as effective as gamma radiation in promoting tumors. The gamma irradiated rats live longer than the neutron exposed animals, even though the gamma dose was twice as high. (P.C.H.)

**31388** (ANL-6535(p.28-32)) PROGRESS REPORT: DISEASES AND CARE OF LABORATORY ANIMALS. FURTHER STUDIES ON THE DIAGNOSIS OF PSEUDOMONAS AERUGINOSA INFECTION OF MICE. Robert J. Flynn and Isabel Greco (Argonne National Lab., Ill.).

Since the practical diagnosis of Pseudomonas aeruginosa infection depends upon the detection of pyocyanin production, studies were made to determine the best medium to use for pyocyanin production and the best specimen to use to detect infected animals. It was found that Wensinck's glycerol broth, seven days' incubation, and chloroform extraction was the best medium and technique for the production and detection of pyocyanin. Comparative cultures of water bottles, feces, and saliva were made to determine the best specimen. The culturing of water bottle samples from cages with many mice was found to be more accurate than the culturing of composite fecal samples. (P.C.H.)

**31389** (ANL-6535(p.33-5)) INDUCTION OF OSTEOSARCOMAS IN MICE BY X-IRRADIATION. Miriam P. Finkel, Patricia Berstrand-Jinkins, and Birute O. Biskis (Argonne National Lab., Ill.).

Experiments to determine whether x rays are carcinogenic when administered to the right hind leg of mice in doses of 2000, 3000, 4000, and 5000 r are reported. Changes in the irradiated knee ranged from slight epila-

tion to deep ulceration and even to spontaneous amputation of a portion of the limb. Roentgenograms showed many kinds and degrees of abnormality, including osteosarcomas. Under these conditions, 5000 r seems to have been no more carcinogenic than 2000 r. The results also give the impression that the manifestations of neoplastic change were retarded when damage was severe. (P.C.H.)

**31390** (ANL-6535(p.36-52)) PROGRESS REPORT: TOXICITY AND METABOLISM OF RADIONUCLIDES IN DOGS. II. SEMIANNUAL REPORT FOR PERIOD ENDING DECEMBER 31, 1961. William P. Norris, Louise S. Lombard, Carl E. Rehfeld, and Thomas W. Speckman (Argonne National Lab., Ill.).

Two fission products, $Ce^{144}$ and $Cs^{137}$, were tested to determine their acutely lethal doses ($LD_{50/30}$), and dogs were also injected at lower doses of both isotopes to study their less acute effects. Also, the $LD_{50/30}$ of externally applied, whole-body gamma radiation was approximated experimentally. Doses of 115 $\mu$C/kg of $Ce^{144}$ proved to be very close to the $LD_{50/30}$ for 13-month-old beagle dogs, but the $Cs^{137}$ dose is well in excess of 2000 $\mu$C/kg. Lower doses of $Ce^{144}$ indicate differences in $Ce^{144}$ distribution as compared to that in higher doses. The most conspicuous difference was in the spleen, which contained a much smaller fraction of the injected dose in the low-dose dogs. The $LD_{50/30}$ for gamma radiation was close to 325 r, which corresponds to an absorbed dose of about 250 rads. The effects of gamma radiation and the two radioisotopes on surviving animals are also discussed. (P.C.H.)

**31391** (ANL-6535(p.55-7)) PROGRESS REPORT: EXPERIMENTAL STUDIES ON THE Cu(I,II)-PEROXY THEORY OF RADIOBIOLOGICAL EFFECTS AND THEIR MODIFICATION. Joan F. Fried and Jack Schubert (Argonne National Lab., Ill.).

The effects of sodium cyanide (NaCN) on radiosensitivity in mice and rats was studied at 800 and 850 r. A preliminary toxicity study on NaCN, administered by the intraperitoneal route, was performed. Data indicate that the $LD_{50/30}$ of NaCN is about 6.5 mg/kg for mice and about 4.0 mg/kg for rats. At 850 r, the dose of NaCN necessary to achieve maximum protection was in the minimum lethal range (3.5 mg/kg); at 800 r, the over-all protection was considerably less, but was reached at a lower dose of NaCN (survival of rats treated with 2.5 mg NaCN per kg was 37%; that of the controls was 20%). (P.C.H.)

**31392** (ANL-6535(p.62-5)) THE SIMULTANEOUS DETERMINATION OF $C^{14}$ AND $H^3$ IN BIOLOGICAL MATERIAL, USING THE SCHÖNIGER COMBUSTION TECHNIQUE. Martinus J. Frissel and Walter E. Kisieleski (Argonne National Lab., Ill.).

A method for the simultaneous determination of $C^{14}$ and $H^3$ using nonylamine in ethanol as the absorbing solvent is presented. Results obtained from samples to which were added known amounts of $H^3$, $C^{14}$, or both, in the presence of a representative biological tissue, powdered lyophilized rat liver, are given. Recoveries obtained by the rapid combustion technique indicate that the method is essentially quantitative, and correction for quenching is made directly in the calculation of the activities. Equations are given for calculating the activity of $H^3$ and $C^{14}$ in each others' presence. (P.C.H.)

**31393** (ANL-6535(p.84-9)) PROGRESS REPORT: THE BIOSYNTHESIS OF METHIONINE. UTILIZATION OF S-ADENOSYLMETHIONINE BY MICROORGANISMS. Stanley K. Shapiro (Argonne National Lab., Ill.).

The ability of various microorganisms to utilize S-adenosylmethionine as well as the demethylated product S-adenosylhomocysteine for growth was studied. It was found that the ability to satisfy the methionine requirement of various microorganisms with S-adenosylmethionine is uncommon. Only one mutant utilized both compounds for growth. Cell-free extracts of the organism decomposed S-adenosylmethionine readily to 5'-methylthioadenosine although in vitro the latter compound did not accumulate since it was decomposed as rapidly as it was formed. Another type of methionine mutant also contained the same enzymes that decomposed S-adenosylmethionine, but presumably the genetic block in methionine biosynthesis was beyond the point where 5'-methylthioadenosine could enter the pathway. (P.C.H.)

**31394** (ANL-6535(p.90-5)) PROGRESS REPORT: PROPIONIC ACID METABOLISM. III. THE CONVERSION OF ACRYLATE TO SUCCINATE. Robert W. Swick and Isabelle S. Waldron (Argonne National Lab., Ill.).

The isomerization of methylmalonyl CoA was carried out in the presence of isotopic acrylic acid and the succinate formed was examined for radioactivity in order to test the hypothesis that the thioester is bound to the enzyme and that free acrylic acid might occur as a transient intermediate. Acrylate was incorporated into succinate, however, not via the isomerization of methylmalonyl CoA. It was revealed that acrylyl CoA was formed in the system, reduced to propionyl CoA, and then converted to succinyl CoA by transcarboxylation and isomerization. (P.C.H.)

**31395** (ANL-6535(p.96-9)) EFFECTS OF DEUTERIUM ON MALIC DEHYDROGENASE. John F. Thomson, David A. Bray, and Jacqueline J. Bummert (Argonne National Lab., Ill.).

Maximum velocities and Michaelis constants were measured for DPNH and DPND (reduced by hydrosulfite) in both $H_2O$ and 99% $D_2O$. Information of the effects of deuterium in the system was obtained by the use of the $\alpha$- and $\beta$-stereoisomers of DPND. The solvent effects of $D_2O$ on maximum velocity were nearly the same for all substrates. The effects on the Michaelis constants were pronounced for $\beta$-DPND and $DPND_2$, but rather slight (and in the opposite direction) for $\alpha$-DPND, $\alpha,\beta$-DPND, and DPNH. However, the studies do not give a complete picture of the effect of deuterium on reactions requiring DPNH since only one concentration of substrate (oxalacetate) was used. (P.C.H.)

**31396** (ANL-6535(p.100-3)) EFFECTS OF BUBBLING ON CELL SUSPENSIONS. Robert B. Webb (Argonne National Lab., Ill.).

Factors involved in bubbling loss and its effect on x-ray sensitivity in experiments involving irradiation of bacteria with the gaseous environment controlled by bubbling gas through a suspension of cells was examined. The rate of bubbling loss is directly proportional to flow rate of the gas for a given bubble size and is inversely proportional to bubble size for a given flow-rate. Thus the rate of cell loss seems to be related to the area of the gas-liquid interface in the suspension. From the results, it is concluded that dose-survival curves obtained from cell suspensions with the gaseous environment controlled by bubbling may contain substantial errors. The error can be largely corrected if bubbled unirradiated controls are run in parallel with the experimental material. (P.C.H.)

**31397** (ANL-6535(p.104-11)) GLYCEROL AND WATER EFFECTS ON X-RAY SENSITIVITY IN STAPHYLOCOCCUS AUREUS: EVIDENCE FOR SURFACE ADSORPTION. Robert B. Webb (Argonne National Lab., Ill.).

A surface adsorption mechanism of glycerol protection and a major role for energy transfer through bound water

in x-ray damage mechanisms is reported. Glycerol was added to cell suspensions of Staphylococcus aureus at least 60 min before x irradiation. Maximum protection was approached only at very high concentrations of glycerol. The ratio of the sensitivity in buffer ($k = 0.22\ kr^{-1}$) to the sensitivity in 85% glycerol ($k = 0.024\ kr^{-1}$) was 9.2 to 1. Radiosensitivity in buffer under nitrogen anoxia was much greater than in glycerol in air, and the sensitivity in glycerol was further reduced by the removal of oxygen. The data are consistent with an association between water and the protective action of glycerol. Since maximum protection was approached only at glycerol concentrations higher than 50%, it is proposed that the action of certain protective agents against radiation can be considered in terms of physical adsorption on molecules and surfaces within the cell. (P.C.H.)

**31398** (ANL-6535(p.113-20)) ELECTRON MICROSCOPIC OBSERVATIONS OF THE EFFECT OF X-IRRADIATION ON THE CEREBRAL CORTEX OF THE RAT. Thomas F. McDonald and F. Wassermann (Argonne National Lab., Ill.).

Changes, as seen in the electron microscope, that take place in the cerebral cortex of the rat following a single dose of 26000 r of x radiation are described. Tissues were taken from the cerebral cortex of animals up to the 8th day following irradiation. The results show that the capillaries astrocytes, and neurons of the cerebral cortex became damaged in a sequential manner. In all the sections studied, it was obvious that certain areas were more damaged than others. The damaged areas were microscopic in the early stages, measuring about 50 $\mu$ in diameter, but they became progressively larger in the later stages. The order of damage was found first in the capillaries, next the astrocytes, and finally the neurons. The astrocytes, although second to show damage, were the most severely involved in the later stages. The neurons exhibited relatively high radioresistance. (P.C.H.)

**31399** (ANL-6535(p.123-5)) THE FINE STRUCTURE OF MEIOTIC CHROMOSOMES IN THE PIGEON. Bernard R. Nebel and Elizabeth M. Coulon (Argonne National Lab., Ill.).

A description is given of the synaptinemal complex, which refers to the entire compound structure of two paired pachytene chromosomes and contains two dark parallel rods. This represents a piece of a bivalent pigeon spermatocyte. It is believed that a new picture of the structure of the chromosome is beginning to emerge. (P.C.H.)

**31400** (ANL-6535(p.129-38)) ELECTRON MICROSCOPIC EXAMINATION OF THE WALL OF THE LACUNAE AND CANALICULI IN BONE. F. Wassermann (Argonne National Lab., Ill.).

Electron microscopic examination of sections of both decalcified and undecalcified bone revealed the existence of two layers around the osteocytes. One appeared as a pericellular space with a width of about the same order as that of the Rouget-Neumann sheath. The second layer was represented in decalcified sections by a conspicuous dark line which had diameters of only 200 to 400 Å. It was a new structure, not visible in the light microscope. It could not be distinguished in undecalcified sections since it contained bone crystals and appeared as dark as the rest of the matrix. It belonged to the matrix as a special border region, which differed from the bulk of the matrix in two respects: first, the ground substance, in which crystals were embedded, seemed to be denser than the ground substance of the main part of the matrix; second, the crystals toward the lumina of the lucunae and canaliculi were not bound to collagenous fibrils and were not as well ordered as those tightly packed between the fibrils. The border region of the matrix is thought to have special significance for the exchange of material between the bone matrix and the transport medium of the Rouget-Neumann sheath. (P.C.H.)

**31401** (ANL-6535(p.139-41)) RADIOAUTOGRAPHIC STUDY CONCERNING THE ROLE OF ASCORBIC ACID IN COLLAGEN FIBER FORMATION. F. Wassermann, Walter E. Kisieleski, and Lucille Agemura (Argonne National Lab., Ill.).

Studies were made to determine whether fibroblast is able to absorb the constituents of collagen, especially proline, in guinea pigs suffering from experimental scorbutus. Proline labeled with $C^{14}$ was injected intravenously into guinea pigs that had been tenotomized (Achilles tendon) while suffering from experimental scorbutus. The conclusion from the radiographs: that the role of ascorbic acid is not to enable the fibroblast to absorb the building blocks of collagen but, rather, it must be related to other steps in the complex process of fibrillogenesis is not yet definite. (P.C.H.)

**31402** (ANL-6535(p.142-3)) ACTION SPECTRA AND QUANTUM REQUIREMENTS FOR PHOTOSYNTHETIC PROCESSES. Martin Gibbs, Clanton C. Black, John F. Turner, David W. Krogmann, and Solon A. Gordon (Argonne National Lab., Ill.).

Quantum requirements and action spectrum were determined for TPN reduction and associated ATP formation in an isolated system. Yields in monochromatic light were also studied. Suitable suspensions of spinach chloroplast fragments containing Mg, inorganic phosphate, ADP, TPN, and pyridine nucleotide reductase were irradiated at various loci. The quantum efficiencies for the reactions examined were not independent of wavelength in the visible spectrum between 375 and 680 m$\mu$; they dropped in the green region. This may reflect the lower efficiency of energy transfer by co-pigments in the isolated particles. The ratios of ATP formed to TPN reduced at various wavelengths were below unity. Ratios at the lower intensity were roughly half those at the higher. It was concluded that either the coupling of phosphorylation to nucleotide reduction is non-compulsory, or there is an interaction of different photochemical processes at different wavelengths. (P.C.H.)

**31403** (ANL-6535(p.144-5)) INACTIVITY OF HEXITOLS AND HEXOSES IN THE BIOSYNTHESIS OF AUXIN FROM TRYPTOPHAN. Solon A. Gordon and Evelyn Buess (Argonne National Lab., Ill.).

It was determined whether hexitols and hexoses can substitute for phenols in the deamination and decarboxylation of tryptophan to yield the auxin indoleacetic acid (IAA). The hexoses and hexitols tested at concentrations of $10^{-2}$ M in the incubation medium were: D-sorbitol, m-inositol, D-glucose, fructose, and sucrose. No auxin activity was observed when they were incubated with tryptophan in the absence of enzyme. Each enzyme preparation studied converted tryptophan to IAA. The addition of hexitol or hexose resulted in no significant enhancement. It is inferred that the hexitols interact with kinin-like factors in some manner other than by supplying auxin. (P.C.H.)

**31404** (ANL-6535(p.147-54)) SPECTRAL RESPONSE OF PHOSPHATE METABOLISM IN GERMINATING LETTUCE SEEDS. Kenneth Surrey (Argonne National Lab., Ill.).

The effects of monochromatic light on phosphate metabolism (uptake of $P^{32}$-orthophosphate, acid-soluble organic

phosphates, and $P^{32}$-labeled phospholipid fractions) and its possible role in the initiation of the photoactivated germination process in lettuce seeds were studied. The photoresponse of lettuce seed germination was found to parallel its phosphate metabolic activity. When seeds were continuously irradiated, red light accelerated and far-red suppressed their phosphate uptake and esterification activities. The influence of monochromatic light on phosphate metabolism of seeds, determined after 36 and 64 hr of germination, respectively, indicated maximum potentiation between 550 and 650 mμ, maximum suppression beyond 700 mμ was further suppressed by shorter wavelengths of the ultraviolet spectrum. Photoactivation of phosphate metabolism by the three loci (550, 600, and 650 mμ) of the potentiating spectral band was found to be reversed repeatedly by the far-red (750 mμ) light, and vice versa. (P.C.H.)

**31405** (ANL-6535(p.155-61)) GAMMA-RAY SPECTROSCOPY IN THE UPPER ATMOSPHERE. Philip F. Gustafson (Argonne National Lab., Ill.).

A gamma-ray detector and associated electronic circuitry that may be carried aloft by a moderate size (6000-g) weather balloon is described. By means of the balloon-ground station system, it was possible to obtain gamma spectra of airborne radioactivity in situ. Data from a successful flight reaching an altitude of 120,000 ft are given. A rapid increase in count-rate, due primarily to gamma rays produced by cosmic ray interactions with the atmosphere, was found. The interactions reached a broad maximum at 55000 ft. Additional gamma radiation was encountered coming from nuclear test debris throughout the troposphere (tropopause height – 28000 ft), with intense, discrete, layers of fission product activity discernible at 40000 to 45000 and 62000 to 65000 ft. The net gamma spectrum in the latter layer indicated the presence of $Zr^{95}$-$Nb^{95}$, $Ba^{140}$-$La^{140}$, $Ru^{103,106}$, and other fission nuclides which emit gamma rays in the region of 0.511 Mev. (P.C.H.)

**31406** MUTATIONAL RESPONSE OF HABROBRACON OOCYTES IN METAPHASE AND PROPHASE TO ETHYL METHANESULFONATE AND NITROGEN MUSTARD E. A. Loebbecke and R. C. von Borstel (Oak Ridge National Lab., Tenn.). Genetics, 47: 853-64(July 1962).

Ethyl methanesulfonate (EMS) and nitrogen mustard were used to induce dominant and recessive lethal mutations in the oocytes of the parasitic wasp Habrobracon. Oocytes in the first meiotic metaphase were found to be much more sensitive to EMS and nitrogen mustard than oocytes in first meiotic prophase when dominant lethality was the criterion. In this respect, the action of the chemical mutagens resembles that of x radiation. With recessive lethality as criterion, metaphase I and prophase I oocytes respond differently to x radiation and chemical mutagens. A 20-fold difference prevails after x radiation, with metaphase I being the more sensitive stage. With nitrogen mustard, metaphase I is three to five times more sensitive than prophase I, and with EMS, no significant difference was found between metaphase I and prophase I. (auth)

**31407** A STUDY OF THE INFLUENCE OF EXPERIMENTALLY INDUCED HYPOTHYROIDISM ON ANTIBODY PRODUCTION AND DECAY RATES. Douglas E. Johnstone, Joe W. Howland, and Solomon Michaelson. J. Allergy, 33: 6-11(Jan.-Feb. 1962).

The effect of hypothyroidism induced by intravenous injections of $I^{131}$ on antibody production, the anamnestic response, and on antibody decay rate, compared to normal animals, was studied in 63 rabbits. After initial antigenic stimulation, normal animals reached a higher peak titer on an average of 5 days earlier than hypothyroid animals. Antibody half-life in these animals, as measured by time for antibody concentration to fall 50% from peak titer, was 11.4 days in normal compared to 21.3 days in hypothyroid animals. Following a second antigenic stimulation, normal rabbits reached a peak titer in an average of 6.4 days compared to 15 days for hypothyroid animals. The half-life for both groups was measured by determining the rate of disappearance of passively infused antibody. The half-life, thus measured, in normals was 2.4 ± 0.2 days and was 8.8 ± 1.9 days for hypothyroid animals. The time required for serum-tissue equilibration of infused antibody in normals was 1.0 ± 0.00 days compared to 2.3 ± 1.5 days in hypothyroid animals. (auth)

**31408** PREPARATION OF AUTOLOGOUS $I^{131}$-ALBUMIN FOR METABOLIC STUDIES IN MAN. J. J. Franks, Y. Takeda, and E. B. Reeve (Univ. of Colorado, Boulder). J. Lab. Clin. Med., 60: 619-28(Oct. 1962).

Human albumin has been prepared from fresh serum taken from human subjects, by salt fractionation and filtration, and further purified by step wise elution from DEAE cellulose. Both preparations average better than 95 per cent albumin, with the remainder consisting mainly of alpha-1 globulin. After labeling with $I^{131}$ by a modification of McFarlane's method, by both paper and starch electrophoresis, at least 95 per cent of the $I^{131}$ ran with albumin, and DEAE elution chromatograms showed almost identical distribution of $I^{131}$-albumin and native albumin. Studies with these preparations in the donors of the albumin gave an average catabolic rate of 0.142 gm per kilogram body weight per day, which compares favorably with most previous studies. No significant difference was observed in the results obtained with $I^{131}$-primary albumin and $I^{131}$-fractionated albumin. The use of autologous $I^{131}$-albumin avoids the risk of transmitting virus and the need for heat treatment. (auth)

**31409** SOLAR FLARE EFFECTS ON LIVING ORGANISMS CONFINED IN MAGNETIC FIELDS. W. C. Levengood (Univ. of Michigan, Ann Arbor) and M. P. Shinkle. Nature, 195: 967-70(Sept. 8, 1962).

Solar flares were found to influence progeny yields in the fruit fly Drosophila melanogaster in culture bottles placed on the poles of permanent magnets. The progeny yields varied inversely with the solar flare activity, with the south pole progeny showing a slightly greater variation than the north pole progeny. A small positive correlation was found between the progeny and barometric pressure. For control cultures (no magnetic field), on the other hand, a large positive correlation with pressure but no correlation with solar flares were found. It is assumed that the solar flare effect in magnetic fields is due to ionizing particles, and an empirical relationship including both pressure and solar flare factors was worked out which gave more significant correlations. The solar flare correlation also was higher for magnets oriented east-west than for those oriented north-south. (D.L.C.)

**31410** INDUCTION OF RESISTANCE TO AN ISOLOGOUS TUMOUR BY ULTRA-VIOLET ATTENUATED TUMOUR CELLS. M. I. Cosby, L. G. Nutini, E. S. Cook, and G. S. Sperti (Institutum Divi Thomae, Cincinnati). Nature, 195: 1111-2(Sept. 15, 1962).

Experiments were conducted with u-v as the attenuating agent and the BW 5147 lymphatic leukemia in AKR mice as the tumor-host combination. The animals were treated with the irradiated tumor cell suspensions and challenged 16 days later with a viable cell suspension containing $6.75 \times 10^4$ cells/ml. When the tumor cell concentration was $9 \times 10^6$

cells/ml, a partial resistance to challenge tumor growth was affected by the treatment. On the other hand, when the tumor cell concentration was $3.15 \times 10^7$ cells/ml during irradiation and then diluted to $9 \times 10^6$ cells/ml for the treatment, the challenge tumor growth was stimulated. The first tumor cell suspension after irradiation was found to produce very low quantities of growth-promoting substances which absorbed between 2500 and 2600 A, while the second suspension produced large amounts of these substances. (D.L.C.)

**31411** MEDICAL USE OF BETATRON. Masahiko Hamada. Radioisotopes (Tokyo), 11: 110-22(Feb. 1962). (In Japanese)

**31412** THE USE OF RADIOACTIVE ISOTOPES IN OBSTETRICS AND GYNECOLOGY. REVIEW OF THE LITERATURE 1958-1960. Kazumasa Masubuchi. Radioisotopes (Tokyo), 11: 123-32(Feb. 1962). (In Japanese)

**31413** ELECTRON MICROSCOPY. Fifth International Congress for Electron Microscopy held in Philadelphia, Pennsylvania, August 29th to September 5th 1962. Volume 2. Biology. Sydney S. Breese, Jr., ed. New York, Academic Press, 1962.

A total of 339 preprinted papers is included which treat various biological topics in electron microscopy: techniques, motility mechanisms, nerve cells and tissues, nucleic acids and proteins, nephron, lipoproteins, viruses, tumor viruses, mitotic structures, cytoplasmic organelles, neoplastic cells, extracellular matrices, etc. Separate abstracts were prepared for 8 of the papers which were in scope for NSA. (D.L.C.)

**31414** SOME OBSERVATIONS ON THE VACCINIA VIRUSES TREATED WITH URANYL ACETATE. S. N. Chatterjee and J. K. Sarkar (School of Tropical Medicine, Calcutta). p.S-4 of "Electron Microscopy. Vol. 2." New York, Academic Press, 1962. (In English)

Deposits of vaccinia virus on electron-microscope grids were immersed in solutions of 2 and 5% uranyl acetate for times up to 4 hr. Some of the treated deposits were stained negatively with PTA. Treatment with 2% uranyl acetate for 2 hr made the central core of the virus more electron-opaque, whereas treatment with 5% uranyl acetate for 2 to 4 hr digested specifically the core. Hemagglutinins were observed both inside and outside the virus. The results indicate that 5% uranyl acetate digests the nucleic acids and proteins of the virus and that the proteins lie in the core. (D.L.C.)

**31415** CHANGES OF CELL STRUCTURE BY GAMMA RADIATION ON EMBRYO ROOT CELLS OF OATS. Ingeborg Guenther (Landwirtschaftliche Hochschule Hohenheim, Stuttgart-Hehenheim, Ger.). p.W-8 of "Electron Microscopy. Vol. 2." New York, Academic Press, 1962. (In English)

The effects of strong gamma radiation on germinated oats (Avena sativa) were studied. The germination of oat grains and root growth are retarded with increasing radiation dose. A dose of 500,000 r results in the stopping of the spreading of the roots, which are covered with numerous hairs. The first detectable cell structure changes appeared in the Golgi component at a dose of 50,000 r. The changes in the Golgi component are interpreted to mean that irradiated cells form more wall material than non-irradiated cells; this interpretation is supported by the fact that very thick cell walls of fibrillous structure are formed at a dose of 500,000 r. With a dose of 300,000 r, severe damage appears in the mitochondrites, endoplasmatic reticulum, and proplasts, but the damage is not equally large in all the cells. With a dose of 500,000 r, the plasma structure is completely destroyed. Almost no difference was found between the diameters of the cellulose fibrilles in irradiated and non-irradiated roots. The effects of reactor neutron irradiation were found to be similar to those of gamma irradiation. (D.L.C.)

**31416** INVESTIGATION OF THE EROSION OF TOOTH SECTIONS WITH AN ARGON ION BEAM. A. Boyde and A. D. G. Stewart (London Hospital Medical Coll. and Cambridge Univ., Eng.). p.QQ-9 of "Electron Microscopy. Vol. 2." New York, Academic Press, 1962. (In English)

Polished tooth sections were bombarded with 5-kv argon ions and studied in a scanning electron microscope. The maximum rate of material removed from the surface was estimated to be 1 $\mu$ per minute. The profiles of the eroded surfaces depended only on the thickness removed and not on the rate of removal. Dentine was eroded away faster than enamel, intertubular dentine faster than peritubular dentine, and tuft enamel faster than normal enamel. The differences in sputtering rate are attributed to differences in mineralization and hydroxyapatite crystallite orientation. (D.L.C.)

**31417** ON THE ULTRASTRUCTURAL CHANGES OF THE THYROID IN EXPERIMENTALLY RADIOTHYROIDECTOMIZED RATS. M. Baba (Nihon Univ., Tokyo). p.VV-1 of "Electron Microscopy. Vol. 2." New York, Academic Press, 1962. (In English)

Electron microscopic observations are reported on the morphological changes in the ultrastructure of the thyroid follicular epithelium of rats after administration of $I^{131}$. Morphological changes occurred 7 to 10 days after intraperitoneal injection of 1 mc of dilute $I^{131}$. The mitochondria were changed into electron-dense droplets. Cristae mitochondriales were broken up. Changes in endoplasmic reticulum are described. (D.L.C.)

**31418** IMMEDIATE AND DELAYED EFFECTS OF IONIZING RADIATION ON HEPATIC CELLS. Sergio A. Bencosme, V. I. Kalnins, and H. F. Stich (Queen's Univ., Kingston, Ont.). p.VV-2 of "Electron Microscopy. Vol. 2." New York, Academic Press, 1962. (In English)

The effects of whole-body x irradiation and partial hepatectomy at various times after irradiation on hepatic cells were studied. The most striking changes were seen in liver cells shortly after irradiation; large pale bodies were found in areas rich in smooth endoplasmic reticulum. It is concluded that non-specific subcellular abnormalities were developed shortly after irradiation followed by a second wave of abnormalities when the cells undergo mitoses stimulated by partial hepatectomy. None of the changes could be correlated to the abnormal chromosome complements. (D.L.C.)

**31419** ALTERATIONS IN FROG SKIN AFTER HEAVY GAMMA IRRADIATION. Norman E. Kemp (Univ. of Michigan, Ann Arbor). p.VV-3 of "Electron Microscopy. Vol. 2." New York, Academic Press, 1962. (In English)

Adult female frogs were irradiated with 50,000 rep of $Co^{60}$ gamma rays in a single exposure of 0.5 hr. The animals survived 1 to 5 days, and skin sections were studied with optical and electron microscopy. The electron microscopic observations on skin of a frog sacrificed 5 days after irradiation are discussed. (D.L.C.)

**31420** STUDY OF REGENERATED CORTICAL NERVOUS TISSUE AFTER ALPHA PARTICLE IRRADIATION. F. F. Estable-Puig, W. Bauer, J. Blumberg, W. Haymaker, and C. Tobias (Armed Forces Inst. of Pathology, Washington, D. C.; Ames Research Center, Moffett Field, Calif.;

and Univ. of California, Berkeley). p.VV-4 of "Electron Microscopy. Vol. 2." New York, Academic Press, 1962. (In English)

A study was made on the ultrastructure of the cerebral cortex of the rat, long after $\alpha$ irradiation, particularly on the changes occurring on the level of the neostria. The dorsal surface of the rat brain was exposed to a surface dose of 6000 rad of $\alpha$ particles and prepared for electron microscopic studies 9 months after irradiation. Heavy myelination of the neostria was found, and many neutronal processes contain mitochondria, microvesicles, and thickened apposing membranes. Dense granular inclusion bodies are present in the cytoplasm. There is an increase of fibrous astrocytic processes in the irradiated tissue suprajacent to the Bragg's peak band. Some of the functional activity is preserved in spite of the intense atrophy. (D.L.C.)

**31421** THE NATURE OF INCLUSION BODIES IN LEAD POISONING. A. M. Watrach and A. E. Vatter, Jr. (Univ. of Illinois, Urbana and Univ. of Colorado, Denver). p.VV-11 of "Electron Microscopy. Vol. 2." New York, Academic Press, 1962. (In English)

A study was made of the ultrastructural and chemical characteristics of inclusion bodies found in the liver of pigs fed with lead acetate. Acidophilic nuclear inclusion bodies were found in the liver and kidney, and they contain a small amount of DNA and large amounts of protein with a high content of sulfhydryl groups. Electron microscopic studies showed that the essential unit of the bodies was osmiophilic fibrils which are densely packed in the larger bodies. Numerous ferritin granules were dispersed throughout the bodies, and small chromatin aggregates were present at the edges of the bodies. (D.L.C.)

**31422** RADIOISOTOPES AND BONE. A Symposium Organized by The Council for International Organizations of Medical Sciences Established under the Joint Auspices of UNESCO & WHO. P. Lacroix and Ann. M. Budy, eds. Oxford, Blackwell Scientific Publications, 1962. 522p. 77s. 6d.

A symposium on Radioisotopes and Bone was held at Princeton, N. J., Aug. 29 to Sept. 2, 1960. The symposium was under the auspices of the Council for International Organizations of Medical Sciences, the U. S. Atomic Energy Commission, and the International Society of Orthopedic Surgery and Traumatology. Separate abstracts were prepared for the 26 papers presented. (400 references.) (C.H.)

**31423** STUDY OF CALCIUM KINETICS IN CALCIUM- AND PHOSPHORUS-DEFICIENT RATS WITH THE AID OF RADIOCALCIUM. D. Harold Copp and Alice P. Suiker (Univ. of British Columbia, Vancouver). p.1-16 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Calcium-45 was used as a tracer in studies of Ca metabolism in calcium- and phosphorus-deficient rats. When the dietary intake of Ca or P was severely restricted, a number of changes occurred that tended to conserve the element and reduce its utilization. Calcium deficiency caused a reduction in urinary Ca, an increase in intestinal absorption, and a reduction in Ca accretion and bone growth. The parathyroid glands appeared to be hyperfunctional and a normal blood Ca level was maintained. Phosphorus deficiency caused almost complete suppression of excretion of P in urine, and skeletal P was diverted to the soft tissues with consequent loss of mineral by the skeleton. However, the incisors continued to grow and calcification was almost normal. Calcium accretion by the bone was reduced and there appeared to be essentially no new bone growth. Results indicate that in a state of Ca and P deficiency, the metabolic needs of the soft tissues take precedence over those of the skeleton. (C.H.)

**31424** CALCIUM METABOLISM IN MAN. QUANTITATION OF CALCIUM ABSORPTION AND THE EXCRETION INDEX. Felix Bronner, Paul D. Saville, James A. Nicholas, John R. Cobb, Philip D. Wilson, Jr., and Philip D. Wilson. p.17-33 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

The metabolic processes involved in Ca homeostasis in bone include intake, absorption, transport in body fluids, Ca uptake by various processes including deposition in bone, removal from sites of deposition including bone resorption, and excretion via the kidney, intestine, and other routes such as sweat glands. Three methods are described to estimate Ca absorption. These include the partition in urine and feces of intravenously-injected $Ca^{45}$, measurement of $Ca^{45}$ recovered in feces following an oral dose, and comparison of the cumulative excretion of $Ca^{45}$ in urine following an intravenous and an oral dose of $Ca^{45}$. An excretion index is proposed as an experimental measure to evaluate the effect on Ca metabolism of procedures such as immobilization in a plaster cast or of treatment with estrogens. Data are tabulated from illustrative cases. Calcium absorption was also measured in 21 out-patient women ranging in age from 40 to 80 years. The absorption of Ca was found to average 13%, or about one-fourth the level found in children. Many of the adult individuals absorbed no Ca. (C.H.)

**31425** RADIOACTIVE HOTSPOTS, BONE GROWTH AND BONE CANCER; SELF-BURIAL OF CALCIUM-LIKE HOTSPOTS. John H. Marshall (Argonne National Lab., Ill.). p.35-50 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Problems of estimating the effects of internally-deposited radioisotopes upon the human skeleton are discussed. It is pointed out that human cases of radium poisoning provide an experimental measurement of the sensitivity of human bone to long-continued bombardment by internal radiation. The relation between the growth of a typical bone surface, the formation of a hotspot when $Ra^{226}$ or $Ca^{45}$ is injected into the blood, and the subsequent radiation dose delivered to the growing surface of the bone is considered from the point of view of the effectiveness of radioisotopes in the induction of osteogenic sarcomas. A method is described for making approximate calculations of the formation of calcium-like hotspots. Data are reviewed from which it is concluded that the calcium-like hotspots in growing bone following injection of bone-seeking radioisotopes are buried rapidly enough by continuing growth so that the radiation dose accumulated at the bone surface is not many times more than the dose that would be accumulated by the bombardment of the diffuse component alone. The data also indicate that the relative effectiveness of hotspots and the diffuse components may be species-dependent and age-dependent. (C.H.)

**31426** AUTORADIOGRAPHIC STUDY OF BONE WITH $^{45}Ca$. P. Lacroix (Université, Louvain, Belg.). p.51-67 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

The radioautographic demonstration of $Ca^{45}$ deposition in bones is discussed in terms of histological features and the microradiographic picture of the bones. The features are described in detail of radioautograms of compact bone made 7 hr, 12 days, and 6 weeks after administration of $Ca^{45}$. It is pointed out that Ca accretion, fast exchange with a small fraction of minerals localized on the inner surface of the narrow vascular channels, and slow exchange with a

large fraction of minerals distributed in the fully calcified bone are demonstrated by the series of radioautograms. Applications of radioautography in studies on the mode of growth of the skeleton are discussed. (C.H.)

**31427** UPTAKE OF $^{45}$CALCIUM AND $^{14}$CARBON-LABELLED PROLINE BY DEAD AND LIVING BONE. Robert D. Ray (Univ. of Illinois, Urbana and Presbyterian-St. Luke's Hospital, Chicago), Jack Stevens, Irving Lyon, and Robert E. Rowland. p.69-83 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

The uptake of $Ca^{45}$ and $C^{14}$-labeled proline by dead and living bone in young, growing rats was measured. The pattern of isotope distribution was studied in radioautograms. The isotope content of the femur, shafts and ends of living and dead tibias, the blood plasma, and total carcass was determined following autopsy. An equation is presented for calculating the accretion rates for $Ca^{45}$ and $C^{14}$-labeled proline for living and dead bone. Data are tabulated. (C.H.)

**31428** $^{85}$Sr AND $^{47}$Ca IN THE STUDY OF BONE. Goeran C. H. Bauer (Lund Univ. Orthopaedic Clinic, Malmö, Sweden). p.95-104 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

A brief review is presented of applications of tracer techniques in studies of bone physiology. Gamma-emitting isotopes like $Sr^{85}$ and $Ca^{47}$ are recommended for use in studies on the localization and quantitation of metabolites in the bone in man. It is pointed out that trace amounts of these isotopes can be detected safely in vivo without the use of biopsy. Results are reported from typical applications of $Sr^{85}$ and $Ca^{47}$ in studies of bone metabolism in experimental animals and man. (C.H.)

**31429** IN VITRO AND IN VIVO STUDIES WITH BONE-SEEKING ISOTOPES. B. E. C. Nordin, M. Bluhm, and J. MacGregor (Gardiner Inst., Glasgow). p.105-25 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Osteoporosis is a disease of bone protein metabolism that results in a failure of new bone formation. Calcium$^{47}$ was used as a tracer in studies of Ca metabolism in 7 normal subjects and 7 cases of osteoporosis. The daily percentage loss of activity from the exchangeable pool was calculated from the specific activity-time curve and converted into mg/ca day. Calculations were also made of endogenous fecal Ca, urine calcium, and accretion rate. Data are tabulated. Strontium-85 was used as a tracer in additional studies on bone formation in the patients. The Ca and Sr data are compared. A method is proposed for calculating diffusion in bone that is based on the experimental data. (C.H.)

**31430** $^{45}$Ca IN THE STUDY OF BONE GRAFTS IN DOGS. Jonathan Cohen and Constantine J. Maletskos (Children's Medical Center and Harvard Medical School, Boston and Massachusetts Inst. of Tech., Cambridge). p.127-48 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Calcium-45 was used as a tracer in studies of Ca metabolism in grafting procedures in dogs in which homogeneous grafts of refrigerated bone were used. Data are included from studies on both adult animals and puppies. A variation from one animal to the next was noted in all experiments. Data are tabulated. (C.H.)

**31431** ACTION OF PARATHYROIDS ON BONE STUDIED WITH RADIOISOTOPES. Roy V. Talmage (Rice Univ., Houston, Tex.). p.149-65 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Calcium-45, strontium-85, and phosphorus-32 were used as tracers in studies on the effects of parathyroid hormones on the equilibrium of Ca and phosphate concentrations in body fluids and bone. A comparison is made between the solubilities of calcium phosphate salts and basic equilibration levels in rats. Data are tabulated on the effect of parathyroidectomy on the removal of recently administered radioelements from the bones of rats, the concentration of Ca and $PO_4$ in peritoneal washings from nephrectomized rats 1 to 2 hrs following parathyroidectomy, the effect of parathyroidectomy on the removal of radioisotopes from the bones of rats, the effect of pH on removal of Ca by lavage, the effect of Mg or citrate on $Ca^{45}$ removal by lavage when the isotope is administered 18 hr or 2 to 3 weeks before lavage, and the effect of Ca and/or Mg administered by stomach tube on osteoclast count after nephrectomy. Results show that the equilibrating processes are concerned with those areas of bone where growth takes place, thereby aiding bone accretion. The parathyroid hormone increases the metabolic activity of cellular components of bone for resorption of well-formed bone crystals and the return of their ions to body fluids. These two processes are shown to be separate and spatially distinct. (C.H.)

**31432** RICKETS STUDIED WITH ISOTOPES. B. B. Migicovsky and Leonard F. Bélanger (Canada Dept. of Agriculture, Ottawa). p.167-89 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Results are reported from studies on the etiology of rickets in 3-week-old chicks. Calcium-45 was used as a tracer for Ca and $S^{35}$ as a tracer for vitamin D. Results indicate that vitamin D increases the capacity to absorb Ca, Sr, and Ba, but does not affect Be absorption. The vitamin D absorption effect is likely an active one in that energy must be expended to bring about the passage of Ca from intestine to blood. This capacity to absorb Ca is adjustable in the presence of vitamin D. After high Ca intake the capacity to absorb Ca in the presence of vitamin D is reduced as compared to the absorption capacity after low Ca intake. In the presence of vitamin D the rate of accretion by bone is increased, while the resorption rate remains relatively unchanged. Within as short a time as is required for the absorption effect of vitamin D to appear, a change in the cartilage matrix occurs. The alteration of the matrix is followed by mineralization and restoration of a normal cellular composition. The exact biochemical role of vitamin D is still not defined exactly. (C.H.)

**31433** AUTORADIOGRAPHIC LOCALIZATION OF GROWTH HORMONE-INDUCED PROLIFERATION IN BONE AND CERTAIN SOFT TISSUES. C. Willet Asling (Univ. of California, Berkeley) and Lawrence E. Nelson. p.191-5 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Radiographic procedures are described for use in investigations of growth-hormone-induced cellular proliferation of tritiated-thymidine. Results are reported from applications of the technique in studies of the influence of pituitary hormone on proliferation in replacement epithelium and bone. The columnar cells of the intestinal crypts of Lieberkühn in the ileum of normal and hypophysectomized rats were used as test cells for soft tissue proliferation. The biological effectiveness of pituitary hormone was verified by observations on increased width of the epiphyseal plate and restoration of weight gain in growth-hormone-treated hypophysectomized rats. Radioautographic findings are described in detail. (C.H.)

**31434** THE USE OF TRITIATED THYMIDINE IN STUDIES OF CHONDROGENESIS. W. M. Rigal (Nuffield

Orthopaedic Centre, Oxford). p.197-225 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

An in vivo tissue culture method is described for labeling post-fetal hard and connective tissue with tritiated thymidine. The sites of isotope uptake were demonstrated in articular cartilage, epiphyseal anlage, epiphyseal growth cartilage, perichondrial ring, and the metaphysis of growing long bones of the rat and rabbit. Correlation of the uptake of $H^3$-thymidine was made with results obtained by mitotic inhibition, and by in vivo tissue culture together with vascular perfusion to suggest a functional interpretation of the topographical arrangement of the growth apparatus. Superior micro-radioautographs were obtained by in vivo culture rather than by giving the isotope to the living animal. Results are reported and illustrated with a series of photomicrographs of the radioautograms. (C.H.)

**31435** RADIOACTIVE OESTROGENS AND BONE. Ann M. Budy (Univ. of Chicago). p.227-40 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

The effect of estrogens on bone formation and the species specificity of estrogens was studied in mice and rats. Results are reported from studies on the distribution and localization of estrone-16-$C^{14}$ in the bones of mice, $Ca^{45}$ resorption in spongy bone in growing rats, and $H^3$-estradiol localization in the bones of young rats. Applications of radioisotopes in studies of the osteogenic response to estrogens are discussed. (C.H.)

**31436** CHEMICAL AND CRYSTALLOGRAPHIC CONSTITUTION OF BONE: IN VITRO EXCHANGE OF $^{45}$Ca. Marcel J. Dallemagne and Léon Richelle. p.241-59 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Calcium-45 was used as a tracer in studies on the chemical and crystallographic constitution of bone. Results are reviewed from a series of isoionic exchange experiments performed in an attempt to obtain new information about the properties of the excess Ca in bone salts in terms of the theoretical composition of hydroxy-apatite in bone. Results indicate that the uptake of $Ca^{45}$ by bone salts depends on two main processes. These include an exchange occurring between Ca present in the liquid phase and the Ca of the solid phase, and the interaction of mechanisms that control intra-structural ionic exchange, recrystallization, and chemical reactions. Reaction mechanisms involved are discussed. (C.H.)

**31437** CITRATE METABOLISM IN BONE. W. D. Armstrong. p.261-4 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

The formation of citrate in the skeleton and its incorporation into the mineral phase of calcified tissues are discussed. Evidence indicates that the citrate of bone mineral is located on the surface of apatite crystals. In in vivo experiments citrate of bone was found to be exchanged for other ions, such as phosphate. In experiments using $C^{14}$-labeled citrate, the rate of exchange between bone citrate and the same ion occurred at a rate of about 3%/min. Anorganic bone took up significant amounts of citrate when implanted in the peritoneal cavity of rats. This finding indicates that the citrate of bone is not necessarily that formed by the bone cells when the bone mineral is deposited. When dry, fat-free bone was equilibrated with neutral buffered citrate solutions, phosphate, but not Ca, was dissolved. This finding indicates that the role of citrate in bone resorption is related to localized metabolic acidosis. (C.H.)

**31438** AUTORADIOGRAPHIC STUDIES ON BONE SODIUM. J. Vincent (Lovanium Univ., Léopoldville, Congo). p.265-75 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Radioautograms of bone samples were made following neutron activation of $Na^{24}$. The morphological aspects of Na metabolism were studied in human rib, tibia, or clavicle, fixed in 96% ethanol to provide compact bone samples. Transverse sections were placed in a nuclear reactor and exposed to a flux of $3.5 \times 10^{11}$ neutrons/cm$^2$/sec for 6 hr. Sodium-22 was used as a tracer in other studies of Na metabolism in young monkeys. The animals were killed at various intervals after intraperitoneal injection of labeled NaCl and radioautograms were made of bone samples. Bone sections removed from an intact monkey were used to measure the uptake of Na following immersion in $Na^{22}$-labeled NaCl solution. Bone sections were ashed and analyzed for $Na^{22}$. Results indicate that the concentration of Na in compact bone is related to that of Ca and increases with age, while the proportion of recent bone becomes progressively lower. The distribution of $Na^{22}$ in bone was shown to be definitely heterogeneous in experiments of longer intervals. It is concluded that Na is involved in accretion during the formation of new bone, and that the uptake of Na takes place only in the intact mineral portion of bone. (C.H.)

**31439** AUTORADIOGRAPHIC STUDIES OF BONE GROWTH WITH $^{35}$S-SULPHATE. Dominic D. Dziewiatkowski (Rockefeller Inst., New York). p.277-92 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Radioautographic studies of bone growth are described in which sulfate, labeled with $S^{35}$, was used as a tracer. Data are included on the distribution of sulfate in the tissues of young rats following intraperitoneal injection, with emphasis on utilization by epiphyseal cartilages of the knee joints. Knee joints were also removed from litter-mates that had not received the isotope, were cut in half, and incubated for 30, 60, or 120 min in a solution of salts containing $S^{35}$-sulfate. Radioautograms of sections from both injected and incubated bone were compared. Results indicate that chondroitin sulfate plays a role in endochondral ossification. (C.H.)

**31440** $^{35}$S-SULPHATE IN BONE REPAIR OF RATS. Robert B. Duthie (Univ. of Rochester, N. Y.). p.293-316 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Macro- and micro-radioautograms were used in studies of the role of sulfate in bone repair in rats. A total of 144 animals were divided into 8 groups, and each animal had a corresponding control. Sulfate labeled with $S^{35}$ was administered to each rat 24-hr before death. A uniform fracture was carried out in all animals by bone cutting, and they were sacrificed after intervals of 24 and 96 hrs, 7, 14, 21, and 28 days. The effects of cortisone, estrogen, parathormone, thyroxine, vitamin A, hyaluronidase, and a histamine-liberator substance on the repair of bone fractures was determined. Measurements of serum inorganic phosphates and serum Ca were made to demonstrate a systemic effect resulting from the administration of the various agents. Results indicate that a sulfated mucopolysaccharide complex, exhibiting metachromasia and $S^{35}$ uptake, was deposited particularly during the formation of periosteal blastema. Cortisone was the only one of the agents tested that affected the utilization of $S^{35}$ and maturation of cartilage cells both in the epiphyseal plate and in the periosteal blastema. (C.H.)

**31441** THE RELATION OF RADIATION DOSE TO RADIATION INJURY IN THE SKELETON, WITH SPECIAL

REFERENCE TO $^{90}Sr$. Janet Vaughan (Churchill Hospital, Oxford). p.317-33 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Problems involved in assessing the hazards from bone-seeking radioisotopes are discussed. Results are reported from a study of $Sr^{90}$ dosimetry in relation to bone damage in rabbits. It is concluded that radiation injury from $Sr^{90}$ in the skeleton and teeth is probably related to the accumulated radiation dose in the osteogenic connective tissue rather than to the dose rate. (C.H.)

**31442** BONE TUMOUR PRODUCTION IN RATS FOLLOWING THE INJECTION OF RADIOACTIVE PHOSPHORUS. N. M. Blackett (Royal Cancer Hospital, London). p.335-54 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Results are reported from studies on the pattern of bone tumor development in rats following repeated injections of $P^{32}$. An attempt is made to find a relationship between radiation conditions and the subsequent tumor response. (C.H.)

**31443** RADIOISOTOPE INTERACTIONS WITH DENTAL HARD TISSUES. Reidar F. Sognnaes (Univ. of California, Los Angeles). p.355-70 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Applications of radioisotopes in dental research are reviewed. Results are reported from a series of tracer studies designed to illustrate the interchange of ions between saliva and enamel, and between the pulp fluid and dentin; the two-way permeability of the teeth from the pulp outwards and from the saliva inwards; the isotope gradients within the dental hard tissues themselves; following internal administration at various stages of calcification; and the relationship between tooth and bone behavior in response to isotopes in certain metabolic diseases. The data form the basis for a comparison of the functional potentialities of teeth and bones. (C.H.)

**31444** THE VASCULAR ROLE IN CALCIFICATION AND OSTEOGENESIS. Joseph Trueta (Oxford Univ.). p.371-91 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Results are reported from a series of studies on osteogenesis in callus formation in rabbits. A method of vascular perfusion is described that was developed to permit satisfactory injection of very small capillaries. A mixture of equal parts of 2% Berlin Blue and a fine Ba suspension known as micropaque was used as the injection medium. After decalcification the injected bones were examined by microradiography and the vascular patterns were studied in transparency photography made under a microscope. Tissue cultures were also used and radioautograms were prepared following the injection of tritiated thymidine. Results showed that each new division of the cells of the proliferative part of the column helps to push further away the vessels of the epiphyseal side of the growth plate. The cells of the columns then begin to enlarge and become fully giant cells within a short time. Nutritional factors were shown to influence maturation or senescence of the columnar cells more than they were influenced by genetic factors. (C.H.)

**31445** STUDIES OF THE INTERACTIONS OF COLLAGEN AND PHOSPHATE. I. THE NATURE OF INORGANIC ORTHOPHOSPHATE BINDING. Melvin J. Glimcher (Harvard Medical School and Massachusetts General Hospital, Boston) and Stephen M. Krane. p.393-418 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

The role of the organic matrix in the formation of the inorganic crystals of mineralized tissues, such as bone, cartilage, and teeth, is discussed. Results are reviewed from a series of studies on the interaction between collagen fibrils and inorganic orthophosphate ions in solution. Inorganic $P^{32}$-labeled orthophosphate was used as a tracer in investigations of the nature of the chemical bond in phosphate binding, and $P^{32}$ and $P^{31}$ were used as tracers in investigations of the exchange of non-dialysable $P^{32}$-bound collagen with unlabeled orthophosphate, and for the identification of phosphoamino acids in $P^{32}$-labeled collagen. Results are summarized. The relation between the binding of specific ions, or ion clusters, by certain groups in the organic matrix and nucleation is discussed. It is pointed out that the two phenomena are quite distinct and are not synonymous. (C.H.)

**31446** STUDIES OF THE INTERACTIONS OF COLLAGEN AND PHOSPHATE. II. NUCLEOTIDASE ACTIVITY AND BINDING OF NUCLEOTIDE PHOSPHORUS. Stephen M. Krane (Harvard Medical School and Massachusetts General Hospital, Boston) and Melvin J. Glimcher. p.419-41 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Adenosine triphosphatase (ATP-ase) activity and the binding of phosphate liberated from ATP was demonstrated in a variety of collagenous tissues in addition to bone. This enzymatic activity was shown to be extracellular as it remained with the collagen upon purification and appeared to be related to the structural integrity of collagen itself. ATP-8-$C^{14}$ and ADP-8-$C^{14}$ were used as tracers in a series of studies using the long bones of rats; fresh ribs of pickerel, halibut, and cod; operculi of cod; and metatarsals of 9- to 14-week old chicks. Fresh crude preparations of collagen were obtained from carp swim bladder tunic, chicken tendon, rat tail tendon, and bones from rats, fish, and chickens. The use of inhibitors provided further information regarding the specificity of the ATP-ase reaction. Results indicate that the terminal phosphate of ATP was bound to collagen in a manner similar to that demonstrated for inorganic orthophosphate alone. The data suggest that the terminal phosphate was first split from the nucleotide and then bound to collagen partly in a covalent link. (C.H.)

**31447** AGE CHANGES IN THE STRUCTURE AND MINERALIZATION OF BONE TISSUE IN MAN. H. A. Sissons (Inst. of Orthopaedics, London). p.443-65 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Material collected from a number of skeletal sites in more than 70 normal individuals was examined for the relationship between histological structure and tissue turnover in bone. The observations indicate that the development of osteon in early life proceeds from an initial stage characterized by a narrow rim of incompletely mineralized bone to a completed structure consisting of a thick wall of more completely mineralized bone with a narrow central canal. The bone immediately adjacent to the central canal usually shows an even higher mineral content than the rest of the system. Reactivation of this inert surface sometimes occurs, and results in an inner region of new bone of relatively low mineralization. In old age, the stage of an inert surface is sometimes reached while the central canal is still wide, whereas in other cases osteon closure can proceed to the complete obliteration of the central canal. (C.H.)

**31448** ELECTRON MICROSCOPY OF BONE. Robert A. Robinson (Johns Hopkins Univ., Baltimore). p.467-84 of "Radioisotopes and Bone." Oxford, Blackwell Scientific Publications, 1962.

Applications of electron microscopy in studies of sub-

microscopic bone structure are discussed. Observations are reported on the organic matrix, collagen component, mucoprotein, mineralization, intra-crystalline space, water space, and crystal dimensions in relation to isotope exchange. (C.H.)

## Biochemistry, Nutrition, and Toxicology

**31449** THE ROLE OF FREE RADICALS IN BIOLOGICAL OXIDATIONS. E. S. Guzman Barron (Univ. of Chicago). Ann. N. Y. Acad. Sci., 67: 648-60(May 24, 1957).

The concept of free-radical formation during the enzymatic oxidation of 2-electron oxidizable substrates has been challenged by Westheimer. Examples of coupled oxidation-reduction reactions are given in which radiation acts as oxidant or reductant with the formation of intermediate free radicals. These examples indicate that free radicals may indeed be formed in enzymatic oxidations. (D.L.C.)

**31450** THE TRITIUM RATE EFFECT IN TYROSINASE-CATALYZED HYDROXYLATION. Brian J. B. Wood and Lloyd L. Ingraham (Univ. of California, Davis). Arch. Biochem. Biophys., 98: 479-84(Sept. 1962).

A small tritium rate effect was found in the tyrosinase-catalyzed hydroxylation of 3,4-dimethylphenol. A rate effect is in agreement with current theories of aromatic electrophilic substitution. The small size of the effect indicates that the proton does not ionize off but is being pulled off by the enzyme. (auth)

**31451** RADIOACTIVE MATERIAL IN THE BODY. W. Daggett Norwood (General Electric Co., Richland, Wash.). Arch. Environmental Health, 5: No. 2, 167-72 (Aug. 1962).

Radioactive material may enter the body by inhalation, ingestion, or through a break in the skin. Early diagnosis depends to some extent upon an environmental analysis but more directly upon measurements of the radiation from the deposits within the body or in excretions from the body. The hazard from such deposits depends upon such factors as the amount and site of deposition in organs, the half-life of its radiation and time of retention in the critical organ, the type and energy of the radiation emitted, the essentiality of the organs affected, and the sensitivity of the critical organ or tissue to radiation injury. Surface contamination may usually be removed by washing with a copious supply of water and detergent. Traumatically embedded radioisotopes will usually require surgical removal. If the radiation from such deposits is extensive and of a penetrating type, protection must be afforded medical attendants. Decontamination of the gastrointestinal tract is similar to that for inactive chemical poisons which are swallowed. In some cases elimination of a radioactive material may be hastened by treatment with its inactive isotope. There is no effective method for increasing the elimination of insoluble isotopes from the lungs. DTPA, a newly developed chelating agent, appears promising in increasing the elimination of plutonium from the body via the urine. Limited studies indicate that it may be similarly useful in increasing the elimination of other transuranium elements and fission products with the exception of strontium. (33 references.) (auth)

**31452** PRESENCE AND BIOSYNTHESIS OF THYROID HORMONES IN A TUNICATE, CIONA INTESTINALIS L. Jean Roche, Gaetano Salvatore, and Giuseppe Rametta (Università, Naples). Biochim. et Biophys. Acta, 63: 154-65(Sept. 10, 1962). (In French)

A tunicate, Ciona intestinalis L., binds very actively $I^{131}$-ions. The labeled iodine is preferentially located (75%) in the external layer of the tunic. The iodine metabolism is there chiefly oriented toward the biosynthesis of iodothyronines (thyroid hormones). The presence of free thyroxine and 3,5,3′-triiodothyronine in the tissues of Ciona has been established. Biogenesis of 3,5,3′-triiodothyronine and thyroxine proceeds chiefly in the tunic, in which three fractions of iodoproteins were characterized. Two of these, one soluble in various media, the other bound to insoluble structure, contain 3,5,3′-triiodothyronine, thyroxine and their precursors, 3-monoiodo- and 3,5-diiodotyrosine. The four iodinated amino acids are freed from these proteins by action of pancreatic proteinases and papain. An insoluble residue of iodinated scleroprotein, not hydrolyzed by proteinases, does not take part to endocrine activity; 3-monoiodotyrosine and 3,5-diiodotyrosine only are found in the products of its alkaline hydrolysis. The mechanism of hormonogenesis seems identical in all chordata (urochordata, cephalochordata, and vertebrates). As thyroid hormones are found in these and not in invertebrates lower than urochordata, their appearance in this subphylum can be considered as a fundamental step of biochemical evolution of the thyroid function. Biosynthesis of iodothyronines is characteristic of chordata. It proceeds in all of these, including protochordata, by the same mechanism, but under conditions submitted to the evolution of the secretory tissue through a series of steps, the last of which is the thyroid follicle of vertebrates. (auth)

**31453** REDUCTION OF THE DEPOSITION IN THE BODY OF $Y^{91}$ AND $Ce^{144}$ THROUGH THE USE OF CERTAIN CHELATING AGENTS. N. O. Razumovskii, O. L. Torchinskaia, and V. S. Balabukha. Biophysics (U.S.S.R.) (English Translation), 6: No. 5, 84-7(1961).

A comparative study was made of the use of four chelating agents in preventing the deposition of $Y^{91}$ and $Ce^{144}$ in the body, and in accelerating their excretion from it. The agents used were diethylenetriaminepentaacetic acid (DTPA), ethyl-ether-diaminetetraacetic acid (DEETA), ethylenediaminebisaceticbismethylphosphinic acid (EDPA), and ethylenediaminetetraacetic acid (EDTA). It was shown that the new agents are much more effective than EDTA, and the most effective substances were DTPA and DEETA. (auth)

**31454** TRACING CHANGES IN ISOTOPIC COMPOSITION OF Sr, Rb, Ca, K, AND Li WHEN ASSIMILATED BY PLANTS FROM THE NUTRIENT MEDIUM. G. R. Rick, O. N. Petrova, L. A. Misyuk, and L. V. Platonova (All-Union Lenin Academy of Agricultural Sciences, Leningrad). Biophysics (U.S.S.R.) (English Translation), 6: No. 6, 94-7(1961).

The possibility of changes in the isotopic composition of Sr, Rb, Ca, K, and Li assimilated by plants from the nutrient medium was investigated in spring wheat, rice, tomato, and sunflower plants. A mass spectrometer was used to determine the isotopic composition of plant ashes and nutrient solution. Data are tabulated. No change in the isotopic composition was found for the elements tested when assimilated by plants from the nutrient medium. (C.H.)

**31455** RADIOELEMENT REMOVAL BY CHELATING AGENTS: APPLICATION OF MASS ACTION LAWS AND OTHER FACTORS. Jack Schubert (Argonne National Lab., Ill.). Federation Proc., 20, Suppl. 10: 219-21(Sept. 1961).

A procedure is described for testing the effect of chelating agents on the removal of radioactive metals from mammals. The radioelement is injected into the animal and samples of blood are then withdrawn. A known amount of

the chelating agent is added to the blood and measurements are then made of ultrafilterability. Quantitative formulations are presented that relate the efficiency of removal of radioelements to their formation constants with chelating agents and other ligands. The effectiveness of DTPA in the removal of Pu is discussed. Preliminary studies indicated that DTPA treatment given within three days after injection of Pu causes a marked decrease in bone tumor incidence. The effectiveness of chelates in the removal of radiostrontium is discussed briefly. It is pointed out that there are severe limitations since the Sr chelates are always more weakly bound than the corresponding Ca chelates. No practical procedures have been found for removing Sr already fixed in the bone in man. (C.H.)

**31456** STUDIES OF RATES OF TRANSFER OF $D_2O$, $H_2^*$, $Cl^{36}$, $Na^{22}$, AND $Mg^{28}$ ACROSS THE ISOLATED PERICARDIUM OF DOGS. Tsunekazu Takashina, Ralph Lazzara, James A. Cronvich, and George E. Burch (Tulane Univ., New Orleans and Charity Hospital, [New Orleans]). J. Lab. Clin. Med., 60: 662-8(Oct. 1962).

A method is described for the study of the rates of transfer of tracer isotopes ($D_2O$, $H^3$, $Cl^{36}$, $Na^{22}$, and $Mg^{28}$) across the isolated pericardium of dogs. This method has applications in tracer studies in other biologic fields. The mean coefficients of transfer across the isolated pericardium in vitro were as follows: $D_2O$, $3.06 \times 10^{-2}$; $H^3$, $2.81 \times 10^{-2}$; $Cl^{36}$, $1.95 \times 10^{-2}$; $Na^{22}$, $1.75 \times 10^{-2}$; and $Mg^{28}$, $1.00 \times 10^{-2}$ (milliliters per centimeter$^2$ per minute). The coefficients of transfer of $D_2O$ and $H^3$ were essentially the same and faster than those of $Cl^{36}$ and $Na^{22}$, which in turn were faster than those of $Mg^{28}$. These coefficients of transfer were compared with those determined in vivo, which were consistently lower. The coefficient of transfer of $Cl^{36}$ across a pericardial segment frozen overnight and thawed was higher than that across the freshly isolated segment of pericardium. (auth)

**31457** STRONTIUM-90 PLASMA-LEVELS AND EXCRETIONS IN YOUNG ADULTS. Joseph Samachson and Herta Spencer-Laszlo (Veterans Administration Hospital, Hines, Ill.). Nature, 195: 1113-15(Sept. 15, 1962).

A study was conducted on $Sr^{90}$ metabolism in 10 young adult volunteers receiving a constant diet which included 1.1 g Ca/day and 13.4 $\mu\mu$c $Sr^{90}$/day. Fecal excretion of $Sr^{90}$ averaged 86% of intake, and average net absorption was 14%. Correlations are derived for $Sr^{90}$ in urine, plasma, stool, and food. It is concluded that stool analyses are superior to urinary assays for determining $Sr^{90}$/Ca ratios in food and total $Sr^{90}$ ingested. (D.L.C.)

**31458** ON THE PROBLEM OF X-RAY THERAPY IN ANKYLOZING SPONDYLITIS AND IN SOME OTHER NON-MALIGNANT LESIONS IN THE LIGHT OF CURRENT PROTECTION AGAINST IONIZING RADIATION. Juliusz Borejko. Polski Przeglad Radiol. i Med. Nukleame), 26: 317-28(July-Aug. 1962). (In Polish)

The rationality of using x-ray therapy in ankylosing spondylitis and other non-malignant conditions is discussed. Taking into account the accumulated experience in x-ray application in non-malignant lesions, it was concluded that the analgesing effect related strictly to the x-ray application in ankylosing spondylitis appears in about 20% of the patients. In other groups of disease the percentage is even lower. There is little probability that a small part of the patients will develop cutaneous cancer or bone sarcoma. The probability of radioinduced leukemia in the patients is significant, especially in patients who received repeated treatment. The genetic burden in the treatment of the patients must be omitted. (auth)

**31459** THE PATH OF COBALT-60, IONIC OR CHELATED, IN ALBINO RATS AFTER INTRAVENOUS ADMINISTRATION. V. M. Sivaramakrishnan, T. N. Sekhara Varma, S. Brahmanandam, and B. Nagarajan (Cancer Inst., Madras). Proc. Soc. Exptl. Biol. Med., 110: 817-21(Aug.-Sept. 1962).

The path of cobalt-60, administered alone as cobaltous chloride or with any one of the chelating agents 1-nitroso 2-naphthol, SDDC, rubeanic acid, BAL, EDTA, or cysteine, is traced by studying the tissue distribution at various times after intravenous administration to albino rats. With ionic cobalt and with a number of chelates, an initial accumulation of radioactivity in the liver is noted, even though subsequent distribution varies widely. The 1-nitroso 2-naphthol chelate follows the route Blood → Liver → Skin, Bones and Muscles → Excretion. EDTA- and cysteine-chelates exhibit a marked apathy for the liver, but preferentially concentrate in the skin and bones. Quantitatively, the liver, skin, bones, and muscles are the chief tissues of physiological importance in cobalt metabolism. (auth)

**31460** COMPARISON OF IODINE-131 METABOLISM IN DIFFERENT STRAINS OF MICE. Takehiko Tsuchiya, Junichiro Hayakawa, and Tsutomu Sugahara (National Inst. of Radiological Sciences [Japan]). Radioisotopes (Tokyo), 11: 81-5(Feb. 1962). (In Japanese)

Thyroidal iodine metabolism was studied in four strains of mice by use of $I^{131}$. Strain differences were found for iodine uptake, release rate from thyroid, and conversion ratio. Seasonal differences of iodine uptake were found in all strains. There was no apparent relationship between these three parameters of iodine metabolism. It is assumed that the thyroid function in strain of animal can not be determined by one parameter of thyroidal iodine metabolism. The iodine uptake appeared to be influenced by environmental factors and possibly the interaction between the strain of animal and environments. (auth)

**31461** STUDIES ON THE RELATION BETWEEN DENTAL GROWTH AND THYROID GLAND HAZARD BY $^{131}I$. Tomomitsu Higashi, Toshimi Yamaguchi, Shoichi Suga, and Mitsuru Nakashima (Nippon Dental Coll. [Japan]). Radioisotopes (Tokyo), 11: 86-93(Feb. 1962).

The relation between dental growth and thyroid injuries from internal irradiation was studied in fetal and young rats from mothers injected with $I^{131}$ while pregnant. About 0.3% of $I^{131}$, injected in 250 $\mu$c doses during the last period of pregnancy, passed through the placenta to fetuses within 24 hr following injection. Growth retardation was noted in the offspring of rats injected with 1 $\mu$c of $I^{131}$ during pregnancy. Dental impediments were noted in young rats from mothers injected with 1 $\mu$c of $I^{131}$. Histologic changes in dentation were not seen. Paper chromatograms of fetal thyroid tissue revealed monoiodotyrosine, diiodotyrosine, thyroxine, and unknown $I^{131}$-labeled compounds. (C.H.)

**31462** INCORPORATION OF $Sr^{90}$-$Y^{90}$ IN PLANTS: RADIOAUTOGRAPHIC STUDY OF INCORPORATION IN VICIA FABA. Constantino Nuñez. Rev. publs. navales, 14: 1-17(Jan.-Feb. 1961). (In Spanish)

Studies performed in Vicia faba using radioautographic techniques orientated to demonstrate the Sr-90 metabolism, showed the active circulation of the radioelement in the conduction (vascular) system of the plant which contrasts with a low cell incorporation of Sr-90 showed by citoradioautographs. In radioautographs of high resolution, memeristematic cells showed a low protoplasmatic incorporation around the nucleus, with an aspect of perinuclear crown. Radioautographs of stem and leaves showed a progressive and strong decrease of circulation through feeble or nega-

tive macroradioautographs and negative citoradioautographs. These findings suggest that the radioelement circulates actively through the plant without metabolization in parenchymatic tissues or, at least, in a very feeble condition in cellular groups with a very high metabolic activity (meristematic cells of the root), and that Sr-90 distribution is highly reduced in stem and leaves. This behavior would confirm the importance of direct deposition mechanism of Sr-90 from fall-out on the surface of leaves in the first step of food chains. (auth)

**31463** INVESTIGATIONS ON THE BIOLOGICAL BEHAVIOR OF RADIOACTIVE FISSION PRODUCTS IN PREGNANT ANIMALS. III. ENRICHMENT OF RADIOCESIUM IN NURSING RATS AND THE MODIFICATION OF THE Cs RETENTION IN ORGANS OF THE MOTHER DURING THE LACTATION PERIOD. Heinz Kriegel and Elisabeth Weber (Heiligenberg-Instituts, Heiligenberg Baden, Ger.). Strahlentherapie, 118: 363-8(July 1962). (In German)

In a continuation of the investigation on the placental turnover of radiocesium in the rat, the changes of the postpartum cesium content in the young nursing animals caused by the amounts of cesium, which are excreted with the mother-milk, are described. The cesium content in the organs of the mother at the end of the lactation period is decreased by 50% in contrast to the un-pregnant controls. (auth)

**31464** THE QUESTION OF THE TRANSPORT MECHANISM OF RADIONUCLIDES IN THE BLOOD. I. THE TRANSPORT OF $Ce^{144}$, $Pm^{147}$, AND $Y^{90,91}$ IN THE MOUSE SERUM. Friedrich Gensicke (Deutsche Akademie der Wissenschaften, Berlin). Strahlentherapie, 118: 369-74 (July 1962). (In German)

The transport of cerium-144, promethium-147, and radioyttrium in serum is reported. It could be observed that 15 and 30 min after intravenous or intraperitoneal injection the radionuclides mentioned do not form compounds with proteins and lipoproteins. It is very probable, that Ce-144 and Pm-147 are transported as metal citrate complexes in serum. The same transport mechanism must be assumed, partly, for radioyttrium. (auth)

**31465** THE TOXICOLOGIC AND PHARMACOLOGIC EFFECTS OF HAFNIUM SALTS. Thomas J. Haley, K. Raymond, N. Komesu, and H. C. Upham (Univ. of California, Los Angeles). Toxicol. and Appl. Pharmacol., 4: 238-46(Mar. 1962).

The toxicology and pharmacology of hafnium salts were investigated. Acute intraperitoneal toxicity of hafnyl chloride is of the delayed type with an $LD_{50}$ per 7 days of 112 (93.3–134.4) mg/kg. Chronic feeding for 90 days at levels of 1.0, 0.1, and 0.01% of the diet produced liver changes at the 1.0% level. No changes were observed in the growth rate or the hemogram. Ocular application produced a transient conjunctivitis. Topical application to intact rabbit skin produced a transient irritation, whereas similar studies on abraded skin resulted in nonhealing ulcers. Intradermal injections also produced localized irritation and scar formation. Hafnyl chloride had a depressant effect upon the isolated rabbit and guinea pig ileum. In the intact cat, the compound produced hypotension and death by cardiovascular collapse and respiratory paralysis. The chemical had no effect on the responses to acetylcholine, epinephrine, or histamine or those elicited by stimulation of the cervical sympathetic or vagus nerves. (auth)

**31466** FUNDAMENTALS AND RESULTS OF IN VIVO MEASUREMENTS OF RADIOACTIVE MATERIALS IN THE HUMAN ORGANISM. H. G. Mehl (Frein Universitat, Berlin). p.99-200 of "Medizinische Grundlagenforschung." Band III. K. Fr. Bauer, ed. Stuttgart, Georg Thieme Verlag. 1960. (In German)

In the present survey of the fundamentals and results of the in vivo measurements of radioactive materials in the human body, the functions, technical problems, and their solutions are reported. As an introduction, the detection sensitivity for incorporated activity for a given radioisotope, the radiogeometric spatial resolution possibilities for the location of the radioisotope in the organism, and the radiospectrometric resolutions for the quantitative analysis of incorporated radioisotopes are described. Then the measurements of the total activity present in the organism, of the activity present in a given organ, and of the distribution of radioactive substances in individual organs and in given tissues are discussed. A special section is devoted to the definition of special terms used. 497 references. (J.S.R.)

## Fallout and Ecology

**31467** (TID-16593) QUARTERLY REPORT OF THE COLORADO COOPERATIVE WILDLIFE RESEARCH UNIT, JANUARY–MARCH 1962. Volume 15–Number 3. (Colorado State Univ., Fort Collins). Contract AT(11-1)-898. 56p.

Wildlife research is reported on the mule deer and mourning doves. Phases of the deer work include nutrition, range ecology, winter-range calibration, winter-range behavior as determined by environmental factors, and the population structure of the animals using an intensive study area. Production and cooing behavior in primary habitat types are the main emphasis in the dove investigation. Determinations and implications of age structures in selected browse stands are studied. The distribution and behavior of iodine-131 in mule deer environment are also investigated. (N.W.R.)

**31468** SIZING OF THE FALL-OUT AT VIENNA. F. Ernst, O. Preining, and M. Sedlacek (Universität, Vienna). Nature, 195: 986-7(Sept. 8, 1962).

The aerosol at Vienna was sampled for 403.5 hr (Dec. 22, 1961 to Jan. 8, 1962) on filter paper by an aerosol spectrometer. Size and beta activity distributions were measured. The size distribution showed a peak at 1.5 to 2.5μ (Stokes-diameter), while the beta distribution showed that the beta activity was mainly attached to particles of Stokes-diameters less than 0.7μ. (D.L.C.)

**31469** CAESIUM-134 IN MAN. Kurt Lidén (Univ. of Lund, Sweden) and Igvar Ö. Andersson. Nature, 195: 1040-3 (Sept. 15, 1962).

A 0.80-Mev peak or bump was found in the whole-body gamma spectra of a large number of Swedish and Finnish Lapps. This peak was not found in the spectra of Swedes from the Stockholm and Lund areas, and the peak in Lapps is ascribed to their reindeer meat diet. The half life of the peak was found to be 2.4 ± 0.5 yr, and the gamma-gamma coincidence net spectrum showed two peaks at 0.60 and 0.80 Mev, proving that the 0.80-Mev peak is due to $Cs^{134}$. Measurements on reindeer meat show that $Cs^{134}$ activity is ~1.6% of the $Cs^{137}$ activity. The origins of $Cs^{134}$ in the biosphere are discussed, and the possible release of $Cs^{134}$ by reactor accidents is pointed out. The radiation dose to man from $Cs^{134}$ is calculated. (D.L.C.)

**31470** STRONTIUM-90 FALLOUT FROM THE 1961 SOVIET NUCLEAR DETONATIONS. P. K. Kuroda and J. Nix (Univ. of Arkansas, Fayetteville). Science, 137: 991-2(Sept. 21, 1962).

A steady increase in the $Sr^{90}$ concentration in rain was

observed at Fayetteville, Arkansas, after the 1961 Soviet nuclear test series. Experimental data indicate that the nuclear weapons tested in 1961 were "cleaner" on the average by a factor of five than those exploded in 1957 and 1958. (auth)

## Radiation Effects on Living Tissues

**31471** (IA-753) THE EFFECT OF THYROID IRRADIATION ON THE RELEASE OF LABELLED PBI IN RATS. M. Anbar and M. Inbar (Israel. Atomic Energy Commission, Tel-Aviv). July 1962. 7p.

The effects of thyroid irradiation at doses lower than 10,000 rads on the release of labeled protein-bound iodine (PBI) in rats were studied. It was found that animals form about 3 to 5% PBI in one hour in the range of 20 to 2000 rads, irrespective of the immediate dose absorbed. When examined 24 hr after initial irradiation, a sharp rise in the labeled PBI production rate was observed. No further increase in the rate of PBI reproduction was observed 48, 72, and 96 hr after irradiation and an accumulated dose of 21,000 rads. An almost analogous behavior was observed at lower accumulated doses up to 3000 rads. It was concluded that a certain radiological damage is caused to the thyroid gland of rats at relatively low doses of radiation, of the same order of magnitude delivered by diagnostic tracer doses. The damage manifests itself by an increased production rate of PBI, which is of abnormal composition and contains substantial amounts of a butanol non-extractable component. (P.C.H.)

**31472** (LADC-5323) LONGEVITY OF FIRST AND SECOND GENERATION OFFSPRING FROM MALE MICE EXPOSED TO FISSION NEUTRONS AND GAMMA RAYS. J. F. Spalding (Los Alamos Scientific Lab., N. Mex.). [nd]. Contract [W-7405-eng-36]. 13p.

Life span studies were done on first and second generation offspring from early and late breedings (spermatogonial and post spermatogonial stages) of male RF mice given graded doses of gamma rays or fission neutrons. It was concluded that the life span was not affected by gamma or neutron exposure to the sire or grandsire, either with early or late breedings. The sex ratio of mice born did not support the genetic theory that radiation-induced sex-linked lethals (if present) in irradiated male mice did not result in an increase in the sex ratio (increase in per cent males born) of their offspring. (auth)

**31473** (UR-616) THYROID HORMONE BIOSYNTHESIS IN IRRADIATED CHICK EMBRYOS. Stanley R. Glasser and Franklin T. Brayer (Rochester, N. Y. Univ. Atomic Energy Project). July 20, 1962. Contract W-7401-eng-49. 19p.

X irradiation of 12-day chick embryos increased the 24-hour thyroid uptake of $I^{131}$ of surviving embryos. The chromatographic pattern of the thyroids was markedly altered by a significant increase in the MIT-DIT fraction and of $T_3$. $T_3$ (0.5 μg), either alone or in combination with 600 r x rays, had no effect on growth, survival, or thyroid $I^{131}$ uptake. However, $T_3$ did alter the distribution of iodinated compounds in the embryonic thyroid. The influence of x irradiation on the thyroid chromatographic pattern of $T_3$-treated embryos was qualitatively similar to that seen in untreated irradiated embryos. However, the increase in MIT-DIT was derived at the expense of $T_3$ and $T_4$ rather than from the additional concentration of $I^{131}$. The probable locus of action of radiation on thyroid hormone biosynthesis and the possible significance of the changes on the growth and development of surviving embryos are discussed. (auth)

**31474** (UR-617) THE EFFECT OF X-IRRADIATION AND OF MORBIDITY ON STRONTIUM-90 ABSORPTION AND RETENTION BY RATS. R. C. Baxter and L. W. Tuttle (Rochester, N. Y. Univ. Atomic Energy Project). Aug. 7, 1962. Contract W-7401-eng-49. 19p.

Experiments were devised to study the absorption and retention of $Sr^{90}$ in animals having a controllable morbidity induced by x irradiation. It was found that rats imbibing $Sr^{90}$ solution during the period they were experiencing whole-body radiation absorbed and retained significantly more of the radioisotope than unirradiated controls. Animals receiving $Sr^{90}$ intravenously under comparable conditions showed no difference in retained body burdens. The observations suggested that the differences were due to alterations in gastrointestinal absorption and not to changes in skeletal metabolism. (auth)

**31475** (USNRDL-TR-576) THE RELATIVE POTENCY OF FAST NEUTRONS AND 250 KVP X RAYS IN THE GUINEA PIG. R. D. Phillips, D. J. Kimeldorf, and D. C. Jones (Naval Radiological Defense Lab., San Francisco). Aug. 6, 1962. 32p.

The 30-day lethality response in Hartley strain guinea pigs was determined for fast neutrons and 250 kvp x rays. The LD 50/30 for animals exposed to neutrons was 155 rads, while for animals exposed to x rays it was 273 rads. Most deaths occurred 9-16 days after irradiation, and no deaths occurred before day 7 post-irradiation with either neutrons or x rays. Morphological examination indicated no marked gastrointestinal damage in the guinea pig following either neutron or x-ray exposure in the lethal range. The most frequent finding at autopsy was hemorrhage. Only minimal gastrointestinal damage was seen following supralethal exposures of neutrons or x rays. Body weight, food consumption, and water consumption were also determined for 30 days following irradiation. The relative potency of neutrons with respect to x rays was greater than unity for depressions in the three measurements. Food and water consumption values of survivors returned to control values by 30-days post-irradiation. Body weight, however, remained less than controls for at least 30 days in a dose dependent fashion. The gastrointestinal syndrome was essentially absent in the guinea pig following irradiation. It is suggested that the greater potency of neutrons for lethality in the guinea pig may be explicable on the basis of radiation damage to the hematopoietic system. (auth)

**31476** III. DISSEMINATION OF METASTASES FROM A STRONTIUM-90-INDUCED TRANSPLANTED OSTEOSARCOMA INVESTIGATED BY WHOLE-BODY AUTORADIOGRAPHY. A. Nilsson and S. Ullberg (Research Inst. of National Defence, Sundbyberg, Sweden and Royal Veterinary Coll., Stockholm). Acta Radiol., 58: 6p.(1962). (A/AC.82/G/L.788). (In English)

The distribution of metastases from transplanted osteosarcomas in mice was studied by whole-body autoradiography. Even very small metastases could be detected in the sections with the aid of indications in the autoradiograms because of the high affinity of the tumors for $Sr^{90}$. The metastases did not show higher affinity for bone than for soft tissues. (auth)

**31477** $Sr^{-90}$-INDUCED OSTEOSARCOMAS. Agnar Nilsson (Research Inst. of National Defence, Sundbyberg, Sweden). Acta Vet. Scand., 3: 24p.(1962). (A/AC.82/G/L.785). (In English)

$Sr^{90}(NO_3)_2$ was given as a single intraperitoneal dose to 200 male CBA mice. The dose corresponded to 0.67 μC/g body weight. Osteosarcomas developed in 90% of the mice and lymphatic leukemia in about 5%. The first and the last of the osteosarcomas were detected 181 and 462 days re-

spectively after the injection of $Sr^{90}$. The bone tumors were generally multiple with a mean of 2.2 tumors per mouse and in 10% of the animals 4 or more tumors developed. About 90% of the tumors originated in the parts of the skeleton posterior to the 13th thoracic vertebra. Most of the tumors originated in the long bones, particularly the femur and the tibia, followed by the vertebra, especially the 6th lumbar and first sacral vertebra. Metastases, particularly in the lungs and liver, were observed in a few mice, all of which originated from boneforming tumors and were themselves boneforming. The skeletal tumor can be divided into 2 histological types. These included predominantly non-boneforming, fibroblastic osteosarcoma; or predominantly boneforming, osteoblastic osteosarcoma. The majority (83%) were of the osteoblastic type. Both types of tumor could occur in one animal and even within one bone. An argyrophilic stroma was formed in inverse ratio to the amount of bone formed. The number of mitoses was significantly higher in the fibroblastic than in the osteoblastic tumors; the fibroblastic tumors grew much more rapidly. Serum alkaline phosphatase activity was highly significantly increased for mice with osteoblastic tumors and highly significantly decreased for mice bearing fibroblastic tumors. Both types of tumor could be transplanted isologously. (50 references.) (auth)

**31478** HISTOGENESIS OF $Sr^{90}$-INDUCED OSTEOSARCOMAS. Agnar Nilsson (Research Inst. of National Defence, Sundbyberg, Sweden). Acta Vet. Scand., 3: 16p. (1962). (A/AC.82/G/L.790). (In English)

Five hundred and thirty mice were injected intraperitoneally with $Sr^{90}$ and then killed in groups at intervals from 6 hours to 10 months later. The mice were examined roentgenologically before being autopsied and histological specimens were prepared from the femur, tibia, humerus, thoracic and lumbar vertebrae, ribs, and calotte. The first change, an increase in the number of osteoblasts in the metaphysis, was seen at 4 and 8 days after the injection of $Sr^{90}$. After 8 days there was an increase in the number of osteoclasts. At the same time fiber formation commenced in the marrow adjacent to the endosteum. From 2 to 4 months after injection abundant argyrophilic and collagen fibers as well as a coarse-fibered, basophilic, acellular bone were formed. By 4 to 6 months, intramedullary tumors, osteosarcoma buds, appeared near the distal epiphyseal plate in the femur and the proximal plates in the tibia and humerus, i.e., adjacent to the regions where the radiation reaction was most severe. The majority of the osteoblastic tumors originated in the endosteum, probably from cells in the osteogenic connective tissue. Fibroblastic osteosarcomas arise from the endosteum and also from reticular cells in the medullary cavity. The osteosarcoma buds are often multiple along the endosteum of a bone. The intramedullary tumors are autonomous and transplantable from an early stage in their development. (38 references.) (auth)

**31479** EFFECTS OF RADIOSTRONTIUM ON THE BLOOD AND HAEMATOPOIETIC TISSUES OF MICE. Agnar Nilsson (Research Inst. of National Defence, Sundbyberg, Sweden). Acta Vet. Scand., 3: 15p.(1962). (A/AC.82/G/L.789). (In English)

The effects of radiostrontium on the blood and hematopoietic tissues were studied in 200 CBA mice injected intraperitoneally with 0.67 $\mu$C $Sr^{90}$ per g body weight. Groups of 10 mice given $Sr^{90}$ and 10 control mice were killed at fixed intervals after the injection of $Sr^{90}$. Total leukocyte counts, differential counts, thrombocyte counts, and hemoglobin determinations were made. The spleen and bone marrow in the femur, tibia, humerus, and thoracic and lumbar vertebrae were examined histologically. Bone marrow damage including severe hypoplasia, dilatation of sinusoids, and an increase in fatty tissue, were observed in all bones examined. Damage was more severe in the femur and tibia than in the humerus and vertebrae. The site of marrow damage corresponded fairly well with the distribution pattern for $Sr^{90}$ and the temporal changes in this pattern. Shortly after the injection of $Sr^{90}$, damage was most severe in the distal metaphyseal region of the femur and in the proximal metaphysis of the tibia and humerus. Later, the most severe changes were in the diaphyses of the long bones and regeneration gradually occurred proximally and distally in the long bones immediately adjacent to the epiphyseal plates. Close to the areas of regeneration, marrow damage was usually more persistent and more severe than in other regions with the exception of the initial damage in the metaphysis. Most tumors arise in this site. There was an initial and significant leukocytosis which, by 24 hours, gave way to a leukopenia. Leukopenia then persisted throughout the experimental period (10 months). Hemoglobin levels fell up to the 16th day but from the second month onwards hovered about normal values. The drop in thrombocyte counts was not accompanied by a propensity to hemorrhage. The spleen increased greatly in weight, principally because of great increase in erythro- and megakaryocytopoiesis. (28 references.) (auth)

**31480** THE EFFECTS OF CONTINUOUS IRRADIATION BY TRITIUM ON CELLS CULTIVATED IN VITRO. Agnes N. Stroud (Argonne National Lab., Ill.). Ann. N. Y. Acad. Sci., 67: 11-34(Aug. 29, 1956).

The effects of cultivation in a medium containing $T_2O$ on mitosis of chick embryo skeletal muscle tissue cultures were studied. At low dose rates, structural chromosome changes are rarely seen, although a variety of functional abnormalities in the mitotic process results in the prolongation of visible mitosis, particularly during metaphase. The changes dependent on dose rate rather than total dose are depression of prophase index (cell division rate) and visibly abnormal metaphases. At high dose rates, degeneration of cells through "explosive" death is a prominent phenomenon. (D.L.C.)

**31481** EFFECT OF NEAR-ULTRAVIOLET IRRADIATION ON THE PEROXIDE CONTENT OF SOLUTIONS OF OXIDIZED OR REDUCED DIPHOSPHOPYRIDINE NUCLEOTIDE. M. I. Dolin (Oak Ridge National Lab., Tenn.). Biochem. et Biophys. Acta, 63: 219-21(Sept. 10, 1962). (In English)

Data are tabulated from studies on the effects of temperature and PH and of exposure to near-ultraviolet radiation on the peroxide content of solutions of oxidized or reduced diphosphopyridine nucleotide. (C.H.)

**31482** THE EFFECT OF TEMPERATURE ON THE CROSS-LINKING OF DEOXYRIBONUCLEIC ACID STRANDS BY ULTRAVIOLET RADIATION. Vladimir R. Glišin and Paul Doty (Harvard Univ., Cambridge, Mass.). Biochim. et Biophys. Acta., 61: 458-60(Sept. 17, 1962). (In English)

The effect of temperature of ultraviolet radiation on the cross-linking of desoxyribonucleic acid (DNA) in Salmonella typhimurium was measured at two different ionic strengths. Each sample was preheated to the desired temperature and exposed to a dose of 17,500 ergs/mm. The samples were then denatured in formamide, dialyzed against 0.15 M NaCl and bonded in a CsCl gradient in an analytical centrifuge. Films of all samples were traced with a microdensitometer and the areas representing the

crosslinked and uncrosslinked DNA were calculated. Data showing the biological and physical heterogeneity of denatured ultraviolet-irradiated DNA are presented graphically. (C.H.)

**31483** PARAMAGNETIC RESONANCE SPECTRA OF BIOLOGICAL MATERIALS. IV. THE ACTION OF IONIZING RADIATION OF CHEMICALLY MODIFIED AND DENATURED NUCLEIC ACID PRODUCTS. Pei-ken Sheng, L. A. Bliumnenfel'd, A. E. Kalmanson, and A. G. Pasynskii (Inst. of Chemical Physics, Moscow and Inst. of Biochemistry, Moscow). Biophysics (U.S.S.R.) (English Translation), 6: No. 5, 18-28(1961).

Studies were made of the paramagnetic resonance spectra of γ-irradiated nucleic acids, subjected to denaturation and to various chemical modifications. An increase was demonstrated in the yield of free radicals on γ-irradiation, as a result of these treatments. The results confirm previous observations on the part played by the regular lattice of hydrogen bonds in radiation denaturization of biopolymers. (auth)

**31484** PARAMAGNETIC RESONANCE SPECTRA OF POLYPEPTIDE FILMS AND PROTEINS. M. K. Pulatova, V. N. Rogulenkova, and L. P. Kaiushin (Inst. of Biological Physics, Moscow). Biophysics (U.S.S.R.) (English Translation), 6: No. 5, 29-35(1961).

The paramagnetic resonance spectra of irradiated synthetic films of poly-γ-methyl-L-glutamate with both α-helix and disarranged forms of polypeptide chain, and of various proteins were studied. In a vacuum, undenatured proteins and films having the α-helix form gave a doublet APR signal, which in air became transformed into a singlet. In proteins denatured by heat, and in disordered polypeptide films, after irradiation in vacuum, a doublet paramagnetic resonance spectrum is formed, which does not change in air. The results can be explained by the existence in the proteins and in the films of a regular system of peptide-hydrogen bonds, in the undenatured substances, and by the destruction of this system by denaturation. (auth)

**31485** ULTRAVIOLET FLUORESCENCE OF BONE MARROW AND BLOOD CELLS IN MAN AND ANIMALS IN HEALTH AND IN DISEASE. 2. THEIR CONDITION IN RADIATION SICKNESS. I. Ia. Barskii, E. M. Brumberg, and T. M. Kondrat'eva (Inst. of Cytology and Inst. of Medical Radiology, Leningrad). Biophysics (U.S.S.R.) (English Translation), 6: No. 5, 79-83(1961).

Ultraviolet fluorescence microscopy was used in studies on cells from the bone marrow and circulating blood of rats exposed to a lethal dose of 900 r x radiation. Investigations made 4 hr after irradiation showed marked changes in the ultraviolet fluorescence of the formed elements of both the bone marrow and circulating blood when compared with cells from normal animals. Increased fluorescence of cells of the myeloid series was observed in rats 16 mo after exposure to doses of 500 r x radiation. (C.H.)

**31486** CLINICAL EVALUATION OF AN IN VITRO TEST FOR RADIOSENSITIVITY OF LEUKEMIC LYMPHOCYTES. Robert Schrek, Stanley L. Leithold, Irving A. Friedman, and William R. Best (Veterans Administration Hospital, Hines, Ill. and Cook County Hospital, Chicago). Blood, 20: 432-42(Oct. 1962).

A recently developed slide-chamber method was used to test the radiosensitivity of blood lymphocytes from 80 patients with chronic lymphocytic or lymphosarcoma-cell leukemia. The objective of this study was to determine whether these in vitro tests on sensitivity to x rays had any clinical significance. Two objective criteria were used to measure the clinical reactions of the leukemic patients. The first was the duration of survival of patients following the in vitro test. The second was the minimal leukocyte count of a patient following x ray therapy; the minimal count was expressed as a percentage of the count before therapy. The in vitro radiosensitivity was measured by the 10 per cent survival time of lymphocytes irradiated with 1000 r. Blood lymphocytes from non-leukemic individuals were highly radiosensitive with indices of 1.1 to 2.2 days. In initial tests, the lymphocytes of 61 leukemic patients had the same high sensitivity to x rays as lymphocytes from non-leukemic individuals. In contrast, the lymphocytes of 19 leukemic patients were radioresistant to irradiation with indices of 2.5 to 11 days. The 61 patients with radiosensitive lymphocytes had a median survival time of 22 months after the in vitro test. In contrast, the 19 patients with radioresistant lymphocytes had a median survival time of only 4 months. Clinical x ray therapy caused a greater decline in leukocyte counts in patients with radiosensitive lymphocytes than in those with radioresistant cells. A significant index of 0.60 was obtained for the correlation of in vitro radiosensitivity of lymphocytes and the in vivo decrease in leukocyte counts of patients after x ray therapy. It is concluded that an in vitro finding of radioresistant lymphocytes is correlated with a poor response of the leukocyte count to x ray therapy and a short survival time of the patient. (auth)

**31487** REPORT ON THE X-RAY SENSITIVITY AND THE MITOTIC CYCLE OF THE MOUSE SPERMATOGONIA. Valerio Monesi (Oak Ridge National Lab., Tenn. and Comitato Nazionale per l'Energia Nucleare, Rome). Boll. zool., 28: 227-34(1961). (In Italian)

The x-ray sensitivity of mouse spermatogonia in various stages of the cell cycle was studied, by combining x irradiation and $H^3$-thymidine labeling, 1 hr prior to x-ray exposure. It was shown that damaged spermatogonia die as they reach a definite stage in the mitotic cycle. This stage is metaphase-anaphase for type B spermatogonia and early prophase or late interphase for type A and intermediate spermatogonia. The post-DNA synthetic period of the cell cycle, that goes from the end of DNA synthesis to metaphase, is extraordinarily resistant to x rays. The possibility of relating the differential x-ray sensitivity of the various types of spermatogonia to the different duration of the x-ray resistant period of the mitotic cycle is discussed. (auth)

**31488** EFFECT OF GAMMA RAY AND THERMAL NEUTRON IRRADIATION ON SEED OF KOREAN LESPEDEZA LESPEDEZA STIPULACEA MAXIM. Marion S. Offutt (Univ. of Arkansas, Fayetteville). Crop sci., 2: 325-30(July-Aug. 1962).

The response of Korean lespedeza to gamma ray and thermal neutron treatment of dormant seed was studied through the $R_4$ generation. Seed samples from a single plant selection were treated with dosages ranging from 40 to 80 kr of gamma rays and 1 to 8 hours exposure to thermal neutrons. Dosages of 4, 6, and 8 hours exposure to thermal neutrons were lethal. Except for a 17% increase in plant survival for the 50-kr dosage of gamma rays, the 40-, 50-, 60-, 70- and 80-kr dosages of gamma rays and the 1- and 2-hour dosages of thermal neutrons all reduced seedling emergence, seedling height, plant survival, and seed yield of the $R_1$ generation relative to the control. There was no apparent relationship between gamma ray dosage level and the amount of reduction for any of the characters studied, but with each increase in thermal neutron dosage up to the point of lethality there was a corresponding decrease in seedling emergence, seedling height, plant survival, and seed yield. All plants within 70.0% of the $R_2$

progenies were upright in growth habit (control-type), and all plants within 11.4% of the $R_2$ progenies were procumbent (mutant-type). Plants within the remaining 18.6% of the $R_2$ progenies segregated for growth habit, with 52.0% of the plants being scored as upright and 48.0% as procumbent. There was a spread in maturity of 45 days among the $R_2$ plants. Mean dates of maturity were October 24 for the $R_2$ population, October 10 for the procumbent $R_2$ subpopulation, and October 27 for the upright $R_2$ subpopulation and the control population. The dates of maturity of the $R_3$ and $R_4$ lines were remarkably similar to those of the corresponding $R_2$ plants, relative to the control. A number of morphologically different mutant types in addition to the one for growth habit were observed. These included mutations involving plant size, leaf shape and color, flower structure and color, seed size, and sterility. Disease reaction scores for $R_4$ lines ranged from 1.5 to 7.0 for bacterial wilt and from 2.0 to 3.7 for tar spot based on a scale of 1 to 9. Comparative scores for the control for bacterial wilt and tar spot were 2.8 and 2.5, respectively. Percent leaves varied from a high of 65.6 to a low of 51.9% among 23 $R_4$ lines in comparison with 54.0% for the control. Leaf percentages of 6 of the $R_4$ lines were significantly higher than that of the control, whereas none were significantly lower. None of the 23 $R_4$ lines tested were significantly higher in forage yield than the control, but 5 of this number were significantly lower than the control in this respect. Seed yields of 6 of the 23 $R_4$ lines were significantly higher than that of the control, and 9 were significantly lower. The range in genetic variability of all characters studied was increased above as well as below that of the control, indicating that worth-while advances can be made in the improvement of Korean lespedeza through the use of irradiation. (auth)

**31489** ABSENCE OF BINDING OF IODIDE-$I^{131}$ BY IRRADIATED HUMAN SERUM PROTEIN IN VITRO. H. David Mosier and Marjorie K. Armstrong (Univ. of California School of Medicine, Los Angeles and Pacific State Hospital, Pomona, Calif.). Endocrinology, 71: 671-2(Oct. 1962).

The protein binding of iodide-$I^{131}$ in vitro reported by some investigators has been attributed recently to an irradiation-induced change in the serum proteins. In the present study, human serum was irradiated with iodide-$I^{131}$ alone or with both $I^{131}$ and $Co^{60}$ in vitro. No binding of $I^{131}$ to serum protein was observed after 3-hr electrophoresis of the samples. It is concluded that irradiation of the serum does not enhance in vitro binding of iodide. (auth)

**31490** GENETIC EFFECTS OF IRRADIATION ON EARLY MORTALITY IN SWINE. D. F. Cox and R. L. Willham (Iowa State Univ., Ames). Genetics, 47: 785-8(July 1962).

Survival at birth and over the first three weeks of postnatal life was studied in 182 and 180 litters of pigs from control and irradiated sires, respectively. The paternal exposure of 300 r had no clear influence on litter size at birth or on sex ratio in the first generation. However, the percentage of the total born that survived to three weeks was reduced from 78.5% in the controls to 72.6% in the irradiated group. The effect is apparently the result of detrimental mutations induced in the spermatogonia of the exposed males. (auth)

**31491** ESTIMATION OF THE RELATIVE FREQUENCIES OF X-RAY-INDUCED VIABLE AND RECESSIVE LETHAL MUTATIONS IN THE ad-3 REGION OF NEUROSPORA CRASSA. F. J. de Serres and Rosalie S. Osterbind (Oak Ridge National Lab., Tenn.). Genetics, 47: 793-6 (July 1962).

In a sample of 20 x-ray-induced ad-3 mutations induced in a balanced heterokaryon, 62.5 percent ($^5/_8$) of the ad-3A, 66.7 percent ($^8/_{12}$) of the ad-3B and 100 percent ($^9/_9$) of the ad-3A ad-3B mutations were homokaryotic lethal. Since 76 percent of all x-ray-induced ad-3 mutations are homokaryotic lethal, forward-mutation rates on wild-type strains using the direct method are at least four times too low. The disparity in the forward-mutation rates obtained with x-ray treatment of wild type cannot be attributed to the relative frequencies of homokaryotic viable and lethal mutation, and must reflect differences in locus size or sensitivity. (auth)

**31492** HEMODYNAMIC RESPONSE OF THE DOG TO THERMAL RADIATION. Joseph P. Gilmore, S. W. Handford, J. A. Watkins, R. E. Cranford, R. Jackson, and R. Cureton (Naval Medical Field Research Lab., Camp Lejeune, N. C.). J. App. Physiol., 8: 393-8(Jan. 1956).

Some of the hemodynamic responses of 14 dogs to a severe third-degree 30% surface area burn are described. Evidence is presented which indicates that plasma volume loss into the injured area is not the initiating factor of burn shock. The possible role of a toxin in burn shock is discussed. (auth)

**31493** CHANGES IN DENSITY OF BLOOD SERUM WITH IRRADIATION DOSE AND POST-IRRADIATION PERIOD. Z. Dienstbier and M. Rakovič (Charles Univ., Prague). Nature, 195: 1011-12(Sept. 8, 1962).

Rats were exposed to varying doses of x radiation and the change in blood serum density determined at various times. Maximum changes were observed 6 hr after a 500-r dose. Similar changes were also observed after the application of tris-(β-chlorethyl amine hydrochloride) and colloidal $P^{32}$-labeled Cr phosphate. Possible mechanisms of the changes are discussed briefly. (D.L.C.)

**31494** INDIRECT ACTION OF X-RADIATION ON MAMMALIAN CELLS. K. B. Dawson, E. O. Field, and H. Madoc Jones (Royal Cancer Hospital, London). Nature, 195: 1012-13(Sept. 8, 1962).

Dimethyl sulfoxide was added to cultured HeLa S3 cells and freezing to −79°C carried out. One hour after freezing, the cells were irradiated with 80, 160, and 240 r x rays and kept at −79°C for 24 hr, after which they were rapidly thawed. The radiosensitivity was reduced by freezing; the inactivation dose $D_{37}$ increased from 252 ± 36 r at room temperature to 573 ± 113 r in the frozen state. The results provide evidence for the indirect action of x radiation on mammalian cells. The reasons for the paradoxical findings of Lasnitzki are discussed briefly. (D.L.C.)

**31495** EFFECTS OF IONIZING RADIATION AND PEROXIDES ON HAEMOCYANIN. Jack Schubert and William M. Westfall (Argonne National Lab., Ill.). Nature, 195: 1096-7 (Sept. 15, 1962).

Irradiation experiments were carried out on hemocyanin with 0 to 40,000-r doses of $Co^{60}$ gamma radiation. The results show that the copper of the hemocyanin is oxidized when solutions of oxygenated hemocyanin are irradiated, deoxygenated, and reoxygenated and that the radiation action is due to the formation of hydrogen and organic peroxides. (D.L.C.)

**31496** EFFECT OF RADIATION ON THE ELECTROPHORETIC MOBILITY OF EHRLICH ASCITES TUMOUR CELLS. Sheila Hollingshead (Manchester Coll. of Science and Tech., Eng.) and Doreen Thomason. Nature, 195: 1217(Sept. 22, 1962).

The electrophoretic mobility of tumor cells withdrawn from C3H mice was measured after the mice received a whole-body x-ray dose of 1400 rad. The negative electrophoretic mobility was found to be 1.39 ± 0.03 (S.E.) μ/sec-

v/cm, not significantly different from the value of 1.41 ± 0.04 (S.E.) μ/sec-v/cm observed for unirradiated mice. (D.L.C.)

**31497** BIOSYNTHETIC PATHWAYS IN NUTRITIONALLY DEFICIENT MUTANTS OF MARCHANTIA POLYMORPHA L. M. W. Miller, E. D. Garber, and P. D. Voth (Univ. of Chicago). Nature, 195: 1220-1(Sept. 22, 1962).

A population of 1,588 gemmae of M. polymorpha was exposed to 15,000 r x rays, and a sample of 279 impaired thalli was screened to find nutritionally deficient mutants. Twelve mutants were found, four of which required arginine and/or methionine. The four mutants were tested for growth on defined medium with and without supplements. (D.L.C.)

**31498** FURTHER OBSERVATIONS ON INDUCTION OF TUMORS IN MICE WITH RADIOACTIVE THYMIDINE. Renato Baserga, Hermann Lisco, and Walter Kisieleski (Northwestern Univ. Medical School, Chicago and Argonne National Lab., Ill.). Proc. Soc. Exptl. Biol. Med., 110: 687-90(Aug.-Sept. 1962).

Thymidine labeled with tritium or with carbon-14, when incorporated into DNA of proliferating cells, produces a selective mode of irradiation of cells and cell nuclei. Single and multiple injections of radioactive thymidine have been found to shorten the life span and to produce an increased incidence of tumors in CaF1 mice. The incidence of tumors increased with dose and it was greater in animals injected as young adults than in animals injected later in life. Labeling of embryos in utero with tritiated thymidine likewise increased the incidence of malignant tumors. (auth)

**31499** THE MECHANISM OF RADIATION-INDUCED CREATINURIA. G. B. Gerber, G. Gerber, and K. I. Altman (Univ. of Rochester, N. Y.). Proc. Soc. Exptl. Biol. Med., 110: 797-9(Aug.-Sept. 1962).

Synthesis of creatine in x irradiated, creatinuric rats was determined from the balance of creatine retained in the body and creatine and creatinine excreted in the urine. The rate of release of creatine from the muscle of irradiated rats was determined in irradiated rats which were injected with labeled creatine several days before exposure. The $C^{14}$ activity of urinary creatine and creatinine reflecting the specific activity of free and muscle creatine, respectively, was determined before and after exposure. No alterations in rate of creatine synthesis or in its release from muscle were observed after irradiation. In agreement with previous studies, it was therefore concluded that radiation-induced creatinuria results from a failure of the muscle to utilize creatine synthesized at a normal rate. (auth)

**31500** INHIBITION OF RESPIRATORY ACTIVITY OF SHIGELLA SONNEI BY ULTRAVIOLET IRRADIATION. Mitsuru Nakamura and Carol M. Ramage (Montana State Univ., Missoula). Proc. Soc. Exptl. Biol. Med., 110: 800-3 (Aug.-Sept. 1962).

The respiratory activity of Shigella sonnei was inhibited by uv irradiation. A direct relationship existed between uv dosage and extent of inhibition. The inhibition of respiratory activity varied considerably with different substrates. Irradiated cells which were disrupted by mechanical shaking with glass beads lost practically all respiratory activity. (auth)

**31501** SHORT-DISTANCE GAMMA-RAY THERAPY WITH IRIDIUM-192. J. L. Haybittle (Addenbrooke's Hospital, Cambridge, Eng.). Radiazioni alta energia, 1: No. 1, 32-9(Jan. 1962). (In English)

A brief review is given of the history of the use of iridium-192 as a teletherapy source. An iridium-192 unit is described, and the reasons are given for thinking that such a unit has a place in the radiotherapist's armamentarium as the best and most convenient method of treating superficial lesions at sites adjacent to or involving bone or cartilage. (auth)

**31502** EFFECTS OF GAMMA IRRADIATION ON TULIP. Sohei Obata, Tadashi Katagishi, and Mitsuya Nezu (Toyama Agricultural Experiment Station [Japan]). Radioisotopes (Tokyo), 11: 39-45(Feb. 1962). (In Japanese)

Results are reported from attempts to obtain a bud mutation in tulips after exposure to γ radiation. Genetic alterations were observed for 4 successive seasons. It was concluded that bud mutation of irradiated tulips is due to chimeric alterations. (C.H.)

**31503** EFFECTS OF FRACTIONATION OF THE DOSE ON THE APPEARANCE OF CUTANEOUS REACTIONS FROM IRRADIATION WITH HIGH-ENERGY ELECTRONS. P. G. Paleani Vettori and O. Trucchi (Comitato Nazionale per l'Energia Nucleare, Ispra, Italy). Recentia med., 25: 1-9(Nov. 1960). (CNEN-79). (In Italian)

The effect of dose fractionation on the occurrence of skin reactions during treatment with fast electrons is studied by quantitative methods. The results are discussed and compared with those obtained using other radiations. (auth)

**31504** EFFECTS OF A SINGLE SESSION OF SMALL DOSES OF RADIATION FROM $Co^{60}$ ON THE PERIPHERAL BLOOD OF RHESUS MONKEY (MACACA MULATTA). Siu-choun Ma and Shui-chen Su (Inst. of Biophysics, Academia, Sinica, China). Sci. Sinica (Peking), 11: 1259-68 (Sept. 1962). (In English)

The blood picture of rhesus monkeys was studied in detail after exposure to a single small dose of γ radiation from a $Co^{60}$ source. Dose levels ranged from 5 to 50 r. Data are plotted. Certain characteristic changes were noted in the blood picture after exposure. It is suggested that these changes may be a useful diagnostic tool for exposure to small amounts of radiation. (C.H.)

**31505** THE GROWTH OF HEART CELLS OF WHOLE-BODY IRRADIATED CHICKEN EMBRYOS IN TISSUE CULTURE. Ernst Wendt (Universität, Bonn). Strahlentherapie, 118: 348-58(July 1962). (In German)

Eight day old chicken embryos irradiated with an x-ray dose of 1200 r die 5 to 6 hours after irradiation. Heart tissue of these embryos, taken immediately after irradiation, grows in a normal manner in a synthetic nutritive medium; while heart pieces explanted 3 to 6 hours after irradiation show a significant inhibition of growth in culture. Therefore, the heart tissue is not damaged directly, but indirectly; the longer the tissue remains in the organism after irradiation, the more it is damaged. Indirect radiation damage is not caused by depriving the cells of nutritive substances important for life (deficiency hypothesis). Heart tissue from non-irradiated embryos, which was stored for 3 hours in minced embryonal tissue before cultivation, grew normally in culture. The embryonal tissue was obtained from 8 day old embryos immediately after a lethal whole body irradiation. If the heart cells were exposed to the influence of a homogenate which was obtained from embryos 3 to 6 hours after irradiation, a strong inhibition of growth was observed in the culture of these heart tissues. These results show, that the indirect damage received by cells of the embryonal chicken hearts after a whole body irradiation is caused by the production of poisonous substances, which are not produced in the heart tissue itself, but are brought to it from another place. (auth)

**31506** THE RADIATION INJURY OF GROWING BONES. Joseph Horváth, Franz Horváth, Eugen Juhász, and Ladislaus Urbányi (Medizinische Universität and Forschungsinstitut für Tierzucht, Budapest). Strahlentherapie, 118: 462-78(July 1962). (In German)

Both knee articulations of 6 week old Belgian giant rabbits of the same race were irradiated to determine among other things the amount of the total dose, which causes a recognizable lesion on growing bones. This dose is 1200 r for a field size of 8 × 10 cm at 90 kv, 6 mamp, 30 cm F.S.D., using 3 mm Al filter. Furthermore, the nature, development, and the repair of radiation injuries observed by serial x-ray examinations and associated histologic and chemical analysis were reported. These investigations showed, that the x-irradiation, administered as described above, causes the following effects in growing bones: 1. Acute and to a certain extent, reversible injuries, enlargement, blurring, and excavation of the early calcification zone, which suggests rickets, and 2. chronic persistent injuries (hypertrophic atrophy, retardation of growth, deformations, and bowings). These regression marks could be demonstrated in the roentgenograms about 30 days after completing the x irradiation. The results of the histologic and chemical investigations, published elsewhere, support these roentgenomorphological statements. (auth)

**31507** EFFECTS OF INTERMITTENT AND CONTINUOUS ULTRAVIOLET LIGHT ON GROWTH AND BACK-MUTATION IN OPHIOSTOMA. G. Zetterberg and A. C. Giese (Stanford Univ., Calif.). Exptl. Cell Research, 27: 292-300(Aug. 1962).

The effects of irradiation at different temperatures with intermittent and continuous ultraviolet light (UV) on growth rate and back-mutation in Ophiostoma were studied. For a given dose of UV there was no difference in the effects between continuous and intermittent UV. The back-mutation frequency was found to be independent of dose rate indicating a cumulative effect of UV. (auth)

**31508** SYMPOSIUM ON MUTATION AND PLANT BREEDING, CORNELL UNIVERSITY, ITHACA, NEW YORK, NOVEMBER 28 TO DECEMBER 2, 1960. National Research Council Publication 891. (National Academy of Sciences and National Research Council). 1961. 530p.

A symposium on Mutation and Plant Breeding was held at Ithaca, New York, Nov. 28 to Dec. 2, 1960. Abstracts were prepared for 9 papers presented at this symposium. Other papers covered various aspects of spontaneous and induced mutations, genetic factors affecting population fitness, screening methods in microbiology, the efficacy of mutation breeding, and methods of utilizing plant mutations in crop improvement. (C.H.)

**31509** THE NATURE OF MUTATIONS IN TERMS OF GENE AND CHROMOSOME CHANGES. John R. Laughnan (Univ. of Illinois, Urbana). p.3-29 of "Symposium on Mutation and Plant Breeding." Washington, D. C., National Academy of Sciences—National Research Council, 1961.

Genetic analyses of certain derivatives of the $A^b$ complexes in maize are discussed in detail from the standpoint of extragenic origin and relation to gene mutation. Results of a series of studies showed that noncrossover wild-type reversions from bar occur with a sufficiently high frequency to permit their statistical analysis. It appears that bar duplication has its share of anomalous derivatives. Applications of the findings in studies of variability through regressive changes and the evolution of gene systems are discussed. (26 references.) (C.H.)

**31510** TYPES OF IONIZING RADIATION AND THEIR CYTOGENETIC EFFECTS. Arnold H. Sparrow (Brookhaven National Lab., Upton, N. Y.). p.55-119 of "Mutation and Plant Breeding." NAS-NRC 891. 1961. (BNL-5381)

Certain aspects are reviewed of the physical nature of ionizing radiations and their effects upon nuclei, chromosomes, and genes. The major physical characteristics of a number of the ionizing radiations most important to radiobiologists are presented and some methods of treatment and facilities commonly used are described. The major biological effects, including nuclear and chromosomal changes known to be induced by ionizing radiation in plants or plant cells, are listed and explained briefly. Special attention is given to the problem of chromosome breakage and aberration. The kinetics of the dosage response curves obtained under different conditions for various types of aberrations and mutations are explained and discussed. The possible relationship between chromosome aberration and mutation, and the factors which influence radiosensitivity are considered in some detail. The review is mainly concerned with fundamental aspects of radiation cytogenetics and does not attempt to relate this knowledge to practical problems of plant breeding. It is concluded that further comparative studies of the effects of different physical and chemical mutagens and of various techniques of exposure are urgently needed. In spite of rapid progress being made, our knowledge of radiobiology and radiation genetics leaves much to be desired with respect to our ability to define or predict the most efficient methods for the production of useful mutations in plants. Expansion of the research effort at both basic and applied levels is desirable. (205 references.) (auth)

**31511** CHEMICALS AND THEIR EFFECTS. Charlotte Auerbach (Inst. of Animal Genetics, Edinburgh). p.120-44 of "Symposium on Mutation and Plant Breeding." Washington, D. C., National Academy of Sciences—National Research Council, 1961.

Applications of chemical mutagens in elucidation of the chemical nature of genetic material, the relation between intragenic and intergenic changes, and in the production of specific types of genetic change are discussed. Results are reviewed from a series of studies on the reaction of alkylating agents with desoxyribonucleic acid (DNA), the metagenic effects of urethane, alkaloids, peroxides, formaldehyde, substances related to DNA, and nitrous acid in organisms ranging from bacteria to mammals. The relation between intergenic and intragenic changes, and the production of specific genetic changes by chemical mutagens are discussed. (94 references.) (C.H.)

**31512** EFFECTS OF PREIRRADIATION AND POST-IRRADIATION CELLULAR SYNTHETIC EVENTS ON MUTATION INDUCTION IN BACTERIA. Felix L. Haas, Charles O. Doudney, and Tsuneo Kada (Univ. of Texas, Houston). p.145-72 of "Symposium on Mutation and Plant Breeding." Washington, D. C., National Academy of Sciences—National Research Council, 1961.

Results are reported from a series of studies on the effects of preirradiation and postirradiation cellular synthetic events on mutations induced by ultraviolet irradiation of E. coli. It is pointed out that the processes leading to mutation induction by ultraviolet light are related to gene replication, which is then followed by the influence of the modified gene in enzyme synthesis, and that mutation induction and mutation expression are endpoints in the biochemical events of desoxyribonucleic acid replication and genetic control of enzyme synthesis. Theoretical aspects of mutation induction, investigated by combined biological

and biochemical methods, are discussed. (29 references.) (C.H.)

**31513** USE OF INDUCED MUTANTS IN SEED-PROPAGATED SPECIES. Horst Gaul (Max-Planck-Institut für Züchtungsforschung, Cologne). p.206-51 of "Symposium on Mutation and Plant Breeding." Washington, D. C., National Academy of Sciences—National Research Council, 1961.

The nature of induced mutations in plants is discussed. Emphasis is placed on genetic factors and types of mutants induced in seed-propagated species. Methods of plant breeding are outlined for the production of plant mutations, and problems of induction and selection are reviewed. An attempt is made to evaluate the use of mutations in plant breeding programs. (129 references.) (C.H.)

**31514** THE USE OF INDUCED MUTATIONS FOR THE IMPROVEMENT OF VEGETATIVELY PROPAGATED PLANTS. Nils Nybom (Balsgard Fruit Breeding Inst., Fjälkestad, Sweden). p.252-94 of "Symposium on Mutation and Plant Breeding." Washington, D. C., National Academy of Sciences—National Research Council, 1961.

Results are summarized from mutation experiments in vegetatively propagated plants. Data are included on the induction of mutations in potatoes, chrysanthemums, flower bulbs, carnations, fruit trees, and small fruits such as black currants, grapes, strawberries, and blackberries. Applications of x and $\gamma$ radiation in mutation induction are discussed. The feasibility of using mutations produced as a result of natural variation is compared with the feasibility of using radioinduced mutations in plant breeding programs. (113 references.) (C.H.)

**31515** METHODS OF UTILIZING INDUCED MUTATION IN CROP IMPROVEMENT. James MacKey (Swedish Seed Assn., Svalöf, Sweden). p.336-64 of "Symposium on Mutation and Plant Breeding." Washington, D. C., National Academy of Sciences—National Research Council, 1961.

Factors that influence the genotypic response to progressive mutation in cultivated plants are reviewed. It is pointed out that the metabolic state at time of treatment, the mutagen and dose applied, the method of handling plant material before, during, and after treatment, and the genotypic constitution of the plant material all influence the induction of mutations. Results are reported from studies of mutations in wheat induced by exposure of seeds to x radiation and neutrons. Applications of mutations in crop improvement are discussed. (117 references.) (C.H.)

**31516** FACTORS MODIFYING THE RADIO-SENSITIVITY OF SEEDS AND THE THEORETICAL SIGNIFICANCE OF THE ACUTE IRRADIATION OF SUCCESSIVE GENERATIONS. Richard S. Caldecott and D. T. North (Univ. of Minnesota, St. Paul). p.365-404 of "Symposium on Mutation and Plant Breeding." Washington, D. C., National Academy of Sciences—National Research Council, 1961.

Dormant seeds of barley with an embryo water content of 4% were used for biophysical studies concerned with the influence of pre- and post-irradiation treatment conditions on the manifestation of seedling and genetic injury. Cytological analyses were made at the first meiotic metaphase of $X_1$ plants that were grown to maturity. Data are presented on the effects of hydration before and after irradiation, the effects of either oxygen or nitrogen atmosphere, the relation of seedling height to genetic injury, the relation of oxygen to manifestation of genetic injury, the relation of seedling height at 7 days to interchange frequency at microsporogenesis, and the relation of pre- and post-irradiation temperature to manifestation of injury. The possible genetic and applied significance of the irradiation of successive seed generations of the small-grained cereals in crop improvement is discussed. (31 references.) (C.H.)

**31517** MUTAGENIC SPECIFICITY AND DIRECTED MUTATION. Harold H. Smith (Brookhaven National Lab., Upton, N. Y.). p.413-36 of "Symposium on Mutation and Plant Breeding." Washington, D. C., National Academy of Sciences—National Research Council, 1961.

Experimental evidence is summarized for nonrandomness, differential effect, or specificity of induced mutations in organisms ranging from bacteriophage through bacteria and other microorganisms, higher plants, and animals. It is pointed out that most evidence for mutagenic specificity comes from experiments in which nucleic acid base analogs or alkylating agents were used as the mutagenic agents. It is considered unlikely that mutagens are induced by a common mechanism in all organisms or for all mutagens. The best working hypothesis so far proposed is that hereditary information is determined by the base pair sequence in desoxyribonucleic acid (DNA) and that true intergenic mutations involve fundamentally an alteration in this sequence. Mutations are considered to result from transitions of base analogs that alter the incorporation and replication of DNA or from transversion, which involves a replacement of a purine by a pyrimidine, or vice versa in a given DNA chain. It is concluded that a large gap remains to be bridged between the intra-locus or site specificity observed in microorganisms and the inter-locus or chromosomal region specificity observed in higher plants and animals. The former implies a correlation between hereditary function and structure within DNA molecules while the latter may depend more on the chemical bonds that hold the DNA molecules together and may involve the binding with protein. (75 references.) (C.H.)

## Radiation Sickness

**31518** (TID-16657) STUDIES ON GLUTATHIONE AND 2-AMINOETHANETHIOL. Final Report, June 1, 1958–January 31, 1962. George Gorin and J. Leslie (Oklahoma State Univ., Stillwater. Research Foundation). Aug. 1962. Contract AT(11-1)-71. 7p.

Progress is reported in studies on the biochemical properties of radiation-protective drugs. Emphasis was placed on chemical reactions of 2-aminoethanethiol and glutathione. A method was developed for use in studies on the reactivity of mercapto compounds. Results indicate that the ability of some mercaptans to protect against radiation injury is related to their ability to react with mercapto and disulfide groups in cells. Publications during the period covered by this report are listed. (C.H.)

**31519** COMPLEX AMINE OXIDES WITH RADIOPROTECTANT PROPERTIES. Thomas J. Haley, A. M. Flesher, and L. Mavis (Univ. of California, Los Angeles). Nature, 195: 1012(Sept. 8, 1962).

Mice were fed 250 mg/kg of the compounds 24 hr before 600-r x irradiation. The compounds were 4,5-dimethyl-2-(p-tolyl)-1,3-isoimidazole-1,3-dioxide; 4,5-dimethyl-2-phenyl-2-isoimidazole-1,3-dioxide; 3,4-diphenyl furazan-1-oxide; and 5-quinazolinol-3-oxide. The degree of radio-protection based on total survival varied from 15 to 40%, and the results can be explained as being due to the radical-trapping action of the $-N=C-$ structure. (D.L.C.)

**31520** ROLE OF MERCAPTOETHYLAMINE IN REPEATED MONTHLY EXPOSURES TO GAMMA-RADIATION IN MICE. Michael P. Dacquisto and Shirley M. Benson (Walter Reed Army Inst. of Research, Washington, D. C.). Nature, 195: 1116-17(Sept. 15, 1962).

Experiments were conducted to determine how often mice could be irradiated with adequate mercaptoethylamine (MEA) administered before each exposure. Mice were treated intraperitoneally with 150 mg/kg of MEA 10 to 15 min before each exposure of 975 r $Co^{60}$ gamma radiation at 30- to 32-day intervals. For the first three exposures, survival in the treated mice is good, but recovery from the third and fourth exposures was not complete at the end of the interval. (D.L.C.)

**31521** MONKEY POX DISEASE IN IRRADIATED CYNOMOLOGOUS MONKEYS. Stewart J. McConnell, Yaye F. Herman, Donald E. Mattson, and Leroy Erickson (Walter Reed Army Inst. of Research, Washington, D. C.). Nature, 195: 1128-9(Sept. 15, 1962).

A pox-like infection was observed in two irradiated monkeys ~45 days after whole-body 350-r exposures, and both monkeys died 12 days after the outbreak. Only one of the 20 unirradiated monkeys housed in the same room became infected, and he survived the infection. A virus agent having a cytopathogenic effect was isolated from scabs from one of the infected, irradiated monkeys, and it is classified as a member of the variola-vaccinia groups. A serological survey of the monkey colony revealed that hemagglutination-inhibition antibody to the isolated agent occurred in most of the monkeys housed in the room where the disease occurred, but not in the other monkeys. It is suggested that the virus may be carried by some species of monkeys as a latent virus and that irradiation may cause appearance of clinical disease by decreasing host resistance. (D.L.C.)

**31522** EFFECTS OF PHENCYCLIDINE ON THE RADIOSENSITIVITY OF MICE. J. H. Wilkins and J. H. Barnes (Medical Research Council, Harwell, Berks, Eng.). Nature, 195: 1172-3(Sept. 22, 1962).

Experiments were conducted to determine the protective effects of phencyclidine, a psychotropic drug. When R mice were given 2 to 60 mg/kg phencyclidine intraperitoneally and irradiated with 1025-r x rays 15 min later, no protective effect was detected. When mice were given 4 mg/kg phencyclidine and irradiated with doses of 650 to 950 r 0.5 hr later, a protective effect was found in the mortality responses. The $LD_{50}$ for 30 days was calculated to be 828 r for the phencyclidine-treated (4 mg/kg) mice, as compared with 752.5 r for the controls. (D.L.C.)

**31523** A CORRELATION BETWEEN RADIATION TOLERANCE AND NUCLEAR SURFACE AREA. Simon Iversen (Royal Beatson Memorial Hospital, Glasgow). Nature, 195: 1216-17(Sept. 22, 1962).

Sparrow and Miksche (Science, 134:282) determined the dose (r/day) required to produce severe growth inhibition in 23 species of plants and found a linear relationship between log nuclear volume and log dose. The following equations hold for 6 species: log nuclear volume = 4.42 – 0.82 log dose and log nuclear volume = 1.66 + 0.66 log (DNA content). If all the nuclear DNA is distributed in two peripheral zones, the equations also hold: 2(log nuclear surface area) = 1.33(log nuclear volume) = 2.21 + 0.88 log(DNA content) and 5.88 – 1.09 log dose. For the 23 species, the equation was obtained: 2(log nuclear surface area) = 5.41 – 0.97 log dose. All the slopes are close to the expected value of 1.00. (D.L.C.)

**31524** DEPENDENCE OF RADIATION DIARRHOEA ON THE PRESENCE OF BILE IN THE INTESTINE. Maurice F. Sullivan (Medical Research Council, Harwell, Berks, Eng.). Nature, 195: 1217-18(Sept. 22, 1962). (HW-SA-2646)

The abdomens of albino male rats were exposed to 1000 r of x rays. When the bile was diverted from the lumen of the intestine, diarrhea did not develop. However, in irradiated cannulated rats, diarrhea occurred when bile or bile salts were injected daily into the duodenum. (D.L.C.)

**31525** COMPARATIVE X-RAY SENSITIVITY OF TRIBOLIUM CONFUSUM AND T. CASTANEUM (COLEOPTERA: TENEBRIONIDAE) AT DIFFERENT DEVELOPMENTAL STAGES DURING THEIR LIFECYCLE. H. E. Erdman (General Electric Co., Richland, Wash.). Nature, 195: 1218(Sept. 22, 1962).

The x-ray sensitivities of two ecologically similar species of flour beetles were compared at 8 different ages in the life cycle. The doses required to induce sterility and lethality were determined. The egg was found to be the most radiosensitive stage, and T. confusum was consistently more radiosensitive than T. castaneum. Radiosensitivity was approximately constant during the larval stages, but it increased for the 15-day-old larval stage of T. castaneum and dropped back to normal thereafter. (D.L.C.)

**31526** THERAPY OF RADIOACTIVE POISONING. Heniz Groessinger. Österreichische Ärztezig., 16: No. 7, 481-5(1961). (In German)

As an introduction to a discussion of the therapy of radiation poisoning, damaging radiations, measurement units, and the pathological and physiological bases of radiation injury are discussed. The acute radiation syndrome is described and chronic radiation damage is considered. The general treatment is then indicated. (J.S.R.)

**31527** INVESTIGATIONS ON A BIOLOGICAL RADIATION PROTECTION. XLVI. THE CONTRIBUTION OF THE ADENYLACID SYSTEMS TO THE RADIATION DAMAGE OF MAMMALS. Hanns Langendorff, Hans-Joachim Melching, and Christian Streffer (Universität, Freiburg i. B.). Strahlentherapie, 118: 341-7(July 1962). (In German)

Together with earlier results on the importance of serotonin, pyridoxal-5-phosphate, and compounds of the adenylacid system in radiation damage, the present studies show a radiation protective effect of all adenosin-phosphates, of the cyclic diester 2′-5′-AMP, and of adenosin alone. In combination of substances a special effect of the combination of 5-hydroxy-tryptamine with 2-adenosin-monophosphate is remarkable. (auth)

**31528** INVESTIGATIONS WITH CYSTEIN AND CYSTEAMINE ON X-IRRADIATED FROGS. Ulrich Heckmann and Hans A. Kuenkel (Universitäts-Frauenklinik Hamburg-Eppendorf). Strahlentherapie, 118: 359-62(July 1962). (In German)

An injection of cysteine or cysteamine had no significant influence on either the rate of mortality or on the order of dying of frogs which received a total body irradiation with 1500 r x rays in normothermal (+21°C) and in hypothermal (+5°C) states. Whether the injection was given before or after irradiation made no difference. (auth)

**31529** EFFECTS OF THIOMINE AND DIPHOSPHOTHIAMINE ON THE HEMATOLOGICAL AND BIOCHEMICAL INDICES IN RATS EXPOSED TO $P^{32}$ ISOTOPES. A. Malakhovskii (Scientific Research Inst. of Oncology, Lithuanian SSR). p.117-23 of "Fiziologijos ir Biochemijos Klausimai." Vilnius, Biochemical Society and Inst. of Botany, Lithuanian SSR, 1962. (In Lithuanian)

Applications of diphosphothiamine alone or in combination with thiamine contributed to normalization of disturbances in red and partially in white blood cells of mice exposed to $P^{32}$ and produced a positive effect on biochemical indices. (R.V.J.)

# CHEMISTRY

## General and Miscellaneous

**31530** (K-1548) PHYSICAL AND CHEMICAL PROPERTIES OF SOME MATERIALS USED IN THE ANCO AND ELEMENTAL BORON PROCESSES. E. J. Barber (Oak Ridge Gaseous Diffusion Plant, Tenn.). Oct. 8, 1962. Contract W-7405-eng-26. 42p.

The physical and chemical properties of materials encountered in the separation of the B isotopes by the ANCO process and in the preparation of elemental B were surveyed. The properties of $BF_3$, anisole, anisole-boron trifluoride complex, potassium tetrafluoroborate, and elemental B are examined in detail. The physical and chemical characteristics of $BF_3$ and anisole as separate compounds are well established. Certain pertinent data on the anisole-$BF_3$ complex, such as viscosity and surface tension data, are entirely lacking. The course of the thermal degradation of the complex is not well established and needs further study. The kinetics of the formation of potassium tetrafluoroborate from $BF_3$ and KF are favorable. Many physical and chemical properties of elemental B are not as definitively established as those of $BF_3$ and anisole. Only in recent years has the experimental work been performed on samples of high purity and definite crystal structure. Consequently, much of the early data is merely indicative. The thermodynamic data, in particular, are subject to rather considerable error, and adjustments are to be expected from time to time to incorporate more accurate information. (auth)

**31531** (UCRL-10352) PART I. SEARCH FOR UNSTABLE INTERMEDIATES IN THE CARBOXYLATION REACTION OF PHOTOSYNTHESIS. PART II. SOME REACTIONS OF DIAZOMETHANE IN AQUEOUS SOLUTION. George Agapios Akoyunoglou (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 1962. Contract W-7405-eng-48. 140p.

Carboxydismutase (extracted from chloroplasts of Spinacea oleracea and fractionated with ammonium sulfate) was carboxylated with $HC^{14}O_3^-$ in the presence of $Mg^{++}$ ions, and the complex was isolated in about 45% yield by passage through a Dowex 1 column. $C^{14}O_2$ was quantitatively transferred from $C^{14}O_2$ enzyme to ribulose-1,5-diphosphate (RuDP) yielding $C^{14}$-labeled phosphoglyceric acid (PGA). The carboxylation of carboxydismutase was $Mg^{++}$-dependent. The rate of $C^{14}O_2$ enzyme formation was dependent on the concentration of enzyme, $Mg^{++}$, and bicarbonate. It was also temperature dependent. The formation of the complex was not inhibited by avidin or ATP and it was not ATP-dependent. Preincubation studies with the substrates and inactivation of the enzyme with cold methanol before incubation showed that $Mg^{++}$ with bicarbonate stabilized the enzyme against methanol while RuDP did not. When the enzyme plus $Mg^{++}$ is preincubated with bicarbonate, then treated with methanol followed by incubation with RuDP, some PGA is obtained, but when the enzyme is preincubated with RuDP, no PGA is formed. All efforts failed to produce any evidence for the existence of the postulated diphosphate ester of a beta-keto acid intermediate in the carboxylation reaction of RuDP. This can be explained by any of the following: the amount present is very small; the lifetime very short; or the free beta-keto acid does not occur at all, and the reaction goes through an enzyme ~ $CO_2$ ~ RuDP complex. These efforts included treatment of the products with liquid ammonia and then separation by low temperature paper chromatography, and treatment of the photosynthetic material or the carboxydismutase system with diazomethane. The results provided evidence that the overall carboxydismutase reaction proceeds in two or probably in three steps, with the enzyme-bound $CO_2$ as an intermediate. In other work, $CO_2$ was allowed to react with diazomethane prepared by alkaline hydrolysis of N-methyl-N-nitroso-N'-nitroguanidine. The products were separated, and identified as dimethyl carbonate, methyl carbamate, N-methyl methyl carbamate, and N-dimethyl methyl carbamate. The presence of ammonia was necessary for the formation of methyl carbamate, N-methyl methyl carbamate, and N-dimethyl methyl carbamate when $CO_2$ was allowed to react with diazomethane prepared by alkaline hydrolysis of N-methyl-N-nitroso-p-toluenesulfonamide. Ammonia was found to be present in the ethereal solution of diazomethane prepared by alkaline hydrolysis of N-methyl-N-nitroso-N'-nitroguanidine. The products of the reaction between ammonia, $CO_2$ and diazomethane in aqueous solution are dimethyl carbonate, methyl carbamate, N-methyl methyl carbamate, and N-dimethyl methyl carbamate. A mechanism for their formation is proposed. (auth)

**31532** (UCRL-10394) LONGITUDINAL MIXING IN PACKED GAS-ABSORPTION COLUMNS. William E. Dunn, Theodore Vermeulen, Charles R. Wilke, and Tracy T. Work (California. Univ., Berkeley. Lawrence Radiation Lab.). July 31, 1962. Contract W-7405-eng-48. 67p.

Longitudinal-mixing experiments were conducted in a 2-ft-dia. gas-absorption column by using tracer-injection techniques. The carrier streams were air and water. Empirical Peclet-number correlations are presented for both phases, with 1-in. Beri saddles, 1-in. Raschig rings, and 2-in. Raschig rings used as packing materials. The extent of mixing was much greater in the liquid phase than the gas phase. Gas-phase Peclet numbers decreased with both liquid and gas flow rates. On the other hand, liquid-phase Peclet numbers were found to increase with liquid flow rates, and no quantitative effect of gas rate was observed. Methods are outlined that illustrate the application of the data to mass-transfer systems. By means of examples, it is shown that mixing can contribute significantly to absorption-column design requirements. This factor becomes more pronounced in liquid-phase-controlled diffusion. (auth)

**31533** (UCRL-10448) ENERGY MATRICES OF THE $f^5$ ELECTRON CONFIGURATION. B. G. Wybourne (California. Univ., Berkeley. Lawrence Radiation Lab.). Sept. 1962. Contract W-7405-eng-48. 58p.

The complete electrostatic and spin-orbit matrices of the $f^5$ electron configuration were calculated and are presented tabularly. (auth)

**31534** CALIBRATION OF THE WAVELENGTH SCALE ON SPECTROPHOTOMETERS BY SAMARIUM AND NEODYMIUM CHLORIDES. J. Fog and E. Osnes (Royal Norwegian Air Force, Blindern, Oslo, Norway). Analyst, 87: 760-1(Sept. 1962).

Where spectral lamps cannot be used to calibrate spectrophotometers, the absorption spectra of rare-earth metals are well suited for this purpose. The exact wavelengths of the peaks of $SmCl_3$ and $NdCl_3$ as determined by a Beckmann DU spectrophotometer are given. No spectral shifts occurred between 20 and 30°C. (D.L.C.)

**31535** GAS-CHROMATOGRAPHIC SEPARATION OF ORTHO- AND PARAHYDROGEN ON MOLECULAR SIEVES: ANALYSIS, PREPARATION, AND MEASUREMENT OF CATALYTIC CONVERSION AND OF ADSORPTION. L. Bachmann, E. Bechtold, and E. Cremer (Universitat, Innsbruck, Austria). J. Catalysis, 1: 113-20(May 1962).

Ortho- and parahydrogen was separated on molecular sieves. An apparatus for the preparation of pure ortho-hydrogen and parahydrogen and for the determination of the conversion velocity in the presence of a catalyst is described. If the stationary phase acts as a catalyst during the separation an approximate determination of the conversion velocity can be made from the chromatogram. As there is a simple relationship between the retention volume and the first differential coefficient of the adsorption isotherm, the latter may be obtained from the peak corresponding to one of the components. The adsorption isotherms on molecular sieves Linde 13X and 5A are given. The adsorption enthalpies and the difference of the free enthalpies were also calculated. (auth)

**31536** ADSORPTION ISOTHERMS OF NEON, ARGON, KRYPTON, XENON, HYDROGEN, DEUTERIUM, METHANE, AND TETRADEUTEROMETHANE ON THE HIGHLY GRAPHITIZED CARBON BLACK P33 (2700°). G. Constabaris, J. R. Sams, Jr., and G. D. Halsey, Jr. (Univ. of Washington, Seattle). J. Chem. Phys., 37: 915(Aug. 15, 1962).

Copies of the adsorption isotherms are available ($5.00 for photoprints, $22.50 for 35-mm microfilm) as Document No. 7269 at the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C. The temperature ranges of the isotherms are as follows: Ne, 59 to 94°K; Ar, 90 to 240°K; Kr, 245 to 307°K; Xe, 279 to 315°K; $H_2$ and $D_2$, 90 to 138°K; and $CH_4$ and $CD_4$, 224 to 297°K. (D.L.C.)

**31537** CHEMICAL PREPARATION AND ELECTRON SPIN RESONANCE SPECTRA OF SPECIFIC TRAPPED HYDROCARBON RADICALS. J. E. Bennett and A. Thomas (Shell Research Ltd., Chester, Eng.). Nature, 195: 995 (Sept. 8, 1962).

A general method was developed for preparing specific trapped hydrocarbon radicals by simple chemical reaction. In the method, a thin discontinuous film of Na atoms is deposited onto a freshly prepared moving surface of halogenated hydrocarbon (preferably an iodide) at liquid $N_2$ temperatures in a rotating cryostat. The Na atoms react to form the Na halide and the hydrocarbon radical. A fresh layer of the halogenated hydrocarbon is then deposited to form a matrix with trapped radicals. A sample of the deposit is then transferred to an ESR spectrometer. A table is included which gives the results of ESR spectral and gas-liquid chromatographic analysis of 11 matrixes prepared by this method. (D.L.C.)

**31538** NUCLEAR-ELECTRON DOUBLE RESONANCE IN SOLUTIONS OF POTASSIUM NITROSYL SULPHONATE AND OF POTASSIUM NITROSYL PENTACYANO CHROMIUM(III). R. E. Richards and J. W. White (Oxford Univ.). Proc. Roy. Soc. (London), A, 269: 287-300(Sept. 25, 1962).

The effect on the nuclear resonance spectra of excitation of the electron resonance in solutions of free radicals is studied in a magnetic field of about 3 kOe. The nuclei and electrons are coupled by dipole-dipole interactions. The nuclear polarization produced by a given microwave power varies in a roughly linear manner with the logarithm of the concentration of radical, and this dependence can be interpreted in terms of a set of rate equations relating the buildup and decay of nuclear polarization. The presence of oxygen or of paramagnetic ions reduces the nuclear polarization obtainable, and it is established that this effect depends primarily on the change of the nuclear spin-lattice relaxation time. A quantitative discussion of these effects is given. (auth)

**31539** NUCLEAR-ELECTRON DOUBLE RESONANCE IN SOLUTIONS OF SEMIQUINONES. R. E. Richards and J. W. White (Oxford Univ.). Proc. Roy. Soc. (London), A, 269: 301-10(Sept. 25, 1962).

The Overhauser effect is observed in a field of 3 kOe for the protons and fluorine nuclei in solutions of semiquinone radicals. The presence of free oxygen shortens the nuclear spin-lattice relaxation times and reduces the Overhauser effect. The dependence of nuclear polarization on radical concentration is strongly influenced by specific molecular interactions. In some solutions containing protons and fluorine nuclei, nuclear spin coupling by dipole-dipole interaction can modify in a remarkable way the nuclear polarization obtainable. A method is described for isolating solid substances that produce semiquinone radicals when dissolved in suitable solvents. (auth)

**31540** HIGH-RESOLUTION NUCLEAR-MAGNETIC-RESONANCE SPECTRA OF HYDROCARBON GROUPINGS. VI. THE HYDROGEN SPECTRA OF CARBON-13 SUBSTITUTED ETHANE, ETHYLENE AND ACETYLENE. R. M. Lynden-Bell and N. Sheppard (University Chemical Lab., Cambridge, Eng.). Proc. Roy. Soc. (London), A, 269: 385-403(Sept. 25, 1962).

High-resolution spectra are obtained from the hydrogen nuclei of appropriate isotopic mixtures of ethane, ethylene, and acetylene containing one or two $C^{13}$ nuclei. Analysis of these spectra yields the magnitudes of all but one of the possible internuclear coupling constants in these molecules, including those between pairs of carbon nuclei. Where a given molecule has several coupling constants between pairs of the same type of nuclei the relative signs of these are also determined. Discussion of the experimental results in terms of theory shows that in nearly all cases the contact term is the most important one in determining the magnitude of the coupling constants. Only in the case of the $J_{CC}$ and the long-range $J'_{CH}$ coupling constants of acetylene does it appear to be necessary to consider appreciable contributions from other terms. (auth)

## Analytical Procedures

**31541** (DP-754) AUTOMATIC ANALYSIS OF MOIST HELIUM IN NUCLEAR REACTORS. David L. West (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). Aug. 1962. Contract AT(07-2)-1. 15p.

A gas chromatographic method was demonstrated for the automatic determination of $D_2$, $O_2$, $N_2$, $CD_4$, $CO_2$, and CO in moist He. Standard deviations obtained were 1% of full scale for full-scale ranges as low as 0.1 mole %, and 0.2% of full scale for ranges of 2 mole % or greater. The chromatograph was capable of operation at full-scale ranges as low as 0.5 mole % $D_2$, 0.04 mole % $O_2$, 0.1 mole % $N_2$, 0.1 mole % $CD_4$, 0.2 mole % $CO_2$, and 0.3 mole % CO. (auth)

**31542** (HW-SA-2612) DETERMINATION OF LOW LEVEL $I^{131}$ IN HUMAN THYROIDS RESULTING FROM NUCLEAR TEST FALLOUT. H. E. Palmer and F. Swanberg (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 25, 1962. Contract AT(45-1)-1350. 8p.

A 3-in. × 3-in. NaI scintillation counter was found to be capable of detecting as low as approximately 17 nanocuries

of I-131 in the human thyroid. Following U.S.S.R. tests in the Fall of 1961, I-131 was detected in subjects who regularly drank fresh milk. The body burdens were 18 to 150 picocuries. (auth)

**31543** (IA-712) DIRECT FLAME PHOTOMETRIC LITHIUM DETERMINATION IN DEAD SEA BRINES. J. Yofé and M. Stiller (Israel. Atomic Energy Commission, Tel-Aviv). Apr. 1962. 18p.

A method was developed in which Li is determined by flame-photometry at $\lambda = 670$, 8 mμ in the presence of very high amounts of the cations, Na, K, Mg, Ca. A background correction, interpolated from emission readings at 665 mμ and 675 mμ, is used to correct for the effect of the other cations. Additional standards, (2 to 4 ppm Li), are used to enable the Li concentration to be calculated properly despite the depression of emission that occurs. The analyses of 30 samples, taken from various parts of the Dead Sea, and of brines after precipitation of NaCl and carnallite are presented. (auth)

**31544** (IA-739) THE RADIOASSAY OF TRITIUM IN WATER IN LIQUID SCINTILLATION COUNTERS. THE ISOTOPIC EXCHANGE OF CYCLOHEXENE WITH WATER. M. Anbar, P. Neta, and A. Heller (Israel. Atomic Energy Commission, Tel-Aviv). June 1962. 9p.

The use of cyclohexene as a major component of the liquid scintillation system for use in radioassay of tritium in water is discussed in which a mixture of cyclohexene and toluene is used. Conditions for isotopic exchange between cyclohexene and water were established under which no dilution of $H_2$ occurs except that involved in the exchange of the two species. Radioassay procedures are given. (J.R.D.)

**31545** (LADC-5198) APPLICATIONS OF X-RAY ABSORPTION EDGE ANALYSIS. E. A. Hakkila and G. R. Waterbury (Los Alamos Scientific Lab., N. Mex.). [1961]. Contract [W-7405-eng-36]. 17p.

The x-ray absorption edge technique using secondary targets as radiation sources was applied to the determination of some elements, including Rh, U, Y, Ta, Co, and Ce, that have absorption edges in the wavelength region from 0.53 to 2.2 Å. Polystyrene absorption cells having path lengths between 0.12 and 3.0 cm. were found to be satisfactory. For the longer wavelength radiation, the cells of shorter path length were used, and the sensitivity and precision were increased by using a low density-low molecular weight diluent such as isopropyl alcohol. At optimum concentrations, relative standard deviations in the range of 0.2 to 0.7% were obtained. This secondary target technique requires only standard x-ray fluorescence equipment with simple and inexpensive modifications that can be attached or removed in a few minutes. (auth)

**31546** (ORNL-3342) A COMPREHENSIVE STUDY OF THE NEUTRON ACTIVATION ANALYSIS OF URANIUM BY DELAYED-NEUTRON COUNTING. F. F. Dyer, J. F. Emery, and G. W. Leddicotte (Oak Ridge National Lab., Tenn.). Oct. 16, 1962. Contract W-7405-eng-26. 75p.

The method of neutron activation analysis of U by delayed-neutron counting was investigated in order to ascertain if the method would be suitable for routine application to such analyses. It was shown that the method can be used extensively and routinely for the determination of U. Emphasis was placed on the determination of U in the types of sample materials encountered in nuclear technology. Determinations of U were made on such materials as ores, granite, sea sediments, biological tissue, graphite, and metal alloys. The method is based upon the fact that delayed neutrons are emitted from fission products from the interaction of neutrons with $U^{235}$. Since the $U^{235}$ component of U undergoes most of the fissions when a sample is in a neutron flux, the method is predominately one for the determination of $U^{235}$. The total U in a sample or the isotopic composition of the U in a sample can be determined provided there is a prior knowledge of one of these quantities. The $U^{238}$ content of a test sample is obtained by comparing its delayed-neutron count to that obtained with a comparator sample containing a known quantity of $U^{235}$. (auth)

**31547** (ORNL-TM-363) IDENTIFICATION AND COMPARISON OF PHYSICAL EVIDENCE FOR LAW ENFORCEMENT PURPOSES BY NEUTRON ACTIVATION ANALYSIS. L. C. Bate, M. J. Pro, and G. W. Leddicotte (Oak Ridge National Lab., Tenn.). Sept. 11, 1962. Contract [W-7405-eng-26]. 42p.

A feasibility study was conducted on the application of activation analysis to forensic chemistry. Test portions of automobile paint finish, soot, and soil samples were irradiated in the ORNL Graphite Reactor and the induced gamma radioactivity of each specimen measured with a gamma scintillation spectrometer. Spectral decay curves of the radionuclides in the various specimens classified the materials as to origin. This nondestructive technique is particularly suitable for the analysis of evidence samples that must be maintained in its "as-is" state. (auth)

**31548** (AEC-tr-5328) ISOTOPIC ANALYSIS OF HEAVY WATER BY NUCLEAR RESONANCE. Maurice Goldman. Translated by A. E. Dunklee and F. D. Benton (Savannah River Lab., Aiken, S. C.) from Arch. sci. (Geneva), 10: 247-9(1957). 4p.

Work was carried out to determine the isotopic analysis of heavy water in a reactor and to determine the absolute isotopic composition of a standard of approximate $D_2O$ content of 99.8% by nuclear resonance. The nuclear absorption signals of protons in the samples were observed with a magnet and spectrometer. It was verified that the height of the signal varies linearly with the concentration of protons. For the standard water a concentration of 99.787 ± 0.005% $D_2O$ was obtained. By comparison with this water, it was possible to determine a water sample from a reactor in less than an hour with a precision of 2% on its proton content. (M.C.G.)

**31549** (CEA-tr-R-1570) CHIMIE ANALYTIQUE DU LITHIUM. (Analytical Chemistry of Lithium). Translated from Chapter III, p.74-86 of "Lithium, Its Chemistry, Its Technology." [nd.]. 34p.

The principal problem in the qualitative and quantitative analysis of Li is its complete separation from other alkali metals. A bibliographic survey is made of the analytical chemistry of Li. The methods for the preparation of Li ores and solutions for analysis are given. 43 references. (J.S.R.)

**31550** (CEA-tr-X-436) DOSAGE DU CHROME DANS LES ACIERS INOXYDABLES PAR LA MÉTHODE D'ANALYSE PAR FLUORESCENCE AUX RAYONS X. (Determination of Chromium in Stainless Steels by X-Ray Fluorescence Analysis). K. Monogi. Translated into French from Kogyo Kagaku Zasshi, 64: 98-109(1961). 34p.

The determination of Cr in stainless steels is difficult because frequently considerable differences are produced in the x-ray fluorescence analysis of the principal elements composing the special steels. A new method is presented for the study of Cr concentration using the intensity of the $K_\alpha$ rays of Cr. Experimentally the compensation coefficient relative to the percentage of Ni and Mo was investigated by taking as a basis the quantitative reference ray of the Cr in a 13% Cr steel containing neither

Ni nor Mo. With this reference beam, the percentage of Cr was studied by considering that all the intensities of compensated Cr rays were found on the reference slope. The Cr could then be quantitatively determined with satisfactory results in a large number of stainless steels of various compositions. Moreover, by utilizing the fact that the percentages of Ni and Mo can be determined quantitatively by simple linear ratios if their $K_\alpha$ rays are taken, a practical nomograph was constructed which permits a determination of the three percentages by calculation with the measured intensities of the rays of Cr, Ni, and Mo. With this method, the quantity of Cr in the principal stainless steels was made practicable and, for the first time, was made exact and simple. (tr-auth)

**31551** (EURAEC-339) APPLICATION OF TRANSIENT ELECTROCHEMICAL METHODS TO THE CHEMICAL ANALYSIS OF PRODUCTS CONCERNING NUCLEAR CHEMISTRY. Quarterly Report No. 1, January 1 to March 31, 1962. (Brussels. Universite). Work Performed under United States–Euratom Joint Research and Development Program. Contract 018-60-7-RDB. 17p. A translation.

Factors affecting the amplitude of the kinetic dismutation current were continued. The relative importance of the kinetic current in the presence of different anions was determined to be $ClO_4^- < NO_3^- < Br^- < Cl^- < Sc_4^- < SCN^-$. The importance of kinetic dismutation current control at the time of the quantitative dosage to U was shown. It was found advisable to work under conditions such that the discharge takes place either by 1 or 2 electrons. The discharge of $UO_2^{++}$ ion in $SCN^-$ medium was studied. Specific adsorption effects were detected. The discharge of U in neutral medium was also explored. The hydrolysis of $U^{+6}$ $U^{+5}$, and $U^{+4}$ disturbs the discharge of these ions; the second wave tends to disappear. The electrochemical behavior of U in $CO_3^=$ medium is planned. (J.R.D.)

**31552** DETERMINATION OF $H^3$ AND $C^{14}$ IN BIOLOGICAL MATERIALS USING OXYGEN BOMB COMBUSTION. Herbert Sheppard and Waldtraut Rodegker (CIBA Pharmaceutical Co., Summit, N. J.). Anal. Biochem., 4: 246-51 (Sept. 1962).

A method has been presented which makes possible the determination of 0.4 and 0.1 mμc of $H^3$ and $C^{14}$, respectively, in 1 to 1.5 gm of lyophilized tissue. The sample is combusted in a Parr oxygen bomb under 25 atm pressure of oxygen and the resulting water and carbon dioxide collected and counted in a liquid scintillation spectrometer. (auth)

**31553** DETERMINATION OF TRITIUM IN WHOLE CELLS AND CELLULAR FRACTIONS OF BACILLUS MEGATERIUM USING LIQUID SCINTILLATION TECHNIQUES. John H. Hash (American Cyanamid Co., Pearl River, N. Y.). Anal. Biochem., 4: 257-67(Sept. 1962).

Noncombustive methods for the determination of tritium in Bacillus megaterium using liquid scintillation techniques were developed. The key step involves the dissolution of the cell wall with lysozyme. A fractionation scheme that separates B. megaterium into six soluble fractions, all of which are suitable for incorporation into liquid scintillation solvents, has been developed. Tritiated leucine incorporation was directly proportional to bacterial growth and incorporation was principally into the protein fraction. Tritiated thymidine was not a stable precursor, being converted to thymine, but a portion was incorporated into the nucleic acid fraction. Tritiated diaminopimelic acid was incorporated into the cell wall fraction. It is suggested that these methods have equal applicability for other lysozyme-sensitive organisms, not only for the determination of tritium, but also for other radioisotopes. It is further suggested that, as new cell wall depolymerizing enzymes become available, the methods may be of general applicability. (auth)

**31554** ANODIC DISSOLUTION AND ANALYSIS OF RUTHENIUM ALLOYED WITH MOLYBDENUM AND TUNGSTEN. T. M. Cotton and A. A. Woolf (Associated Electrical Industries, Aldermaston, Eng.). Anal. Chem., 34: 1385-7(Oct. 1962).

Ruthenium–tungsten and ruthenium–molybdenum alloys can be dissolved uniformly by anodic oxidation in aqueous alkali hydroxides. Potassium persulfate is a constituent of the electrolyte for those alloys which tend to passivate. The ruthenium, present in solution as ruthenate and perruthenate, is completely converted to the latter by oxidation in sulfuric acid–sodium bismuthate and distillation of the resulting ruthenium tetroxide into sodium bicarbonate solution. The perruthenate concentration is measured spectrophotometrically at 315 mμ where the molar absorptivity is 2600. Extension of the method to other alloys is indicated. (auth)

**31555** ANION EXCHANGE SEPARATION OF THORIUM USING NITRIC ACID. James S. Fritz and Barbara B. Garralda (Ames Lab., Ames, Iowa). Anal. Chem., 34: 1387-9(Oct. 1962). (IS-435)

Thorium is quantitatively retained by an anion exchange column from aqueous 6M nitric acid solution. Most other metal ions are completely eluted from the column with 75 to 100 ml of 6M nitric acid. Following the separation, thorium is stripped from the column with 0.5M nitric acid and titrated with EDTA. (auth)

**31556** DETERMINATION OF SUBMICROGRAM QUANTITIES OF ALUMINUM IN NATURAL DIAMONDS BY NEUTRON ACTIVATION ANALYSIS. E. C. Lightowlers (Univ. of London). Anal. Chem., 34: 1398-1402(Oct. 1962).

The aluminum content of 18 natural diamond crystals was measured quantitatively by nondestructive neutron activation analysis. Gamma-scintillation spectrometry was employed to detect the 1.78-Mev gamma-emission accompanying the decay of $Al^{28}$ with a 2.27-minute half life. The specimens examined weighed between 5 and 100 mg, and contained between 0.1 and 20 ppm of aluminum by weight. The relative merits of the various methods were evaluated, and sources of errors and interference are discussed. (auth)

**31557** LIQUID SCINTILLATION METHOD FOR MEASURING LOW LEVEL RADIOACTIVITY OF AQUEOUS SOLUTIONS. Lester Levin (Socony Mobil Oil Co., Princeton, N. J.). Anal. Chem., 34: 1402-6(Oct. 1962).

A scintillation mixture for direct measurement of low level radioactivity of aqueous solutions was developed in which up to 10% by volume of sample may be dissolved and counted at temperatures as low as –16°C. High voltage counting at this lower temperature results in appreciably lower background counts than from the higher temperature conditions limited by existing aqueous counting systems. The mixture is particularly applicable, therefore, to low level counting of weak beta emitters. Counting efficiencies of 40% for carbon-14 and up to 5% for tritium are reported. A procedure for determining submicrogram quantities of enriched uranium in urine is presented in which the alpha disintegrations are detected at a level of 2 dpm. The uranium is separated from natural radionuclides in urine by ion exchange. This bioassay is used as a screening method in a health physics program for personnel working with enriched uranium. (auth)

**31558** SOLVENT EXTRACTION METHOD FOR RADIOCERIUM. S. Frederic Marsh, William J. Maeck, Glenn L.

Booman, and James E. Rein (Phillips Petroleum Co., Idaho Falls, Idaho). Anal. Chem., 34: 1406-8(Oct. 1962).

In this method, radiochemical cerium, in fission product mixtures, is oxidized to the quadrivalent state with bivalent silver and extracted as the tetra-n-propylammonium nitratocerate ion-association complex into nitroethane. Cerium is then stripped from the organic phase with hydrogen peroxide–hydrochloric acid and precipitated as cerous oxalate. This method is rapid, safe, and requires a minimum of laboratory technique. It is applicable to aluminum, thorium, zirconium, and stainless steel nuclear fuel matrices and tolerates up to 1 ml of concentrated nitric, sulfuric, perchloric, hydrochloric, and hydrofluoric acids, and 0.25 ml of concentrated phosphoric acid. The relative standard deviation is 1%. (auth)

**31559** DETERMINATION OF RADIOMANGANESE IN FISSION PRODUCT-CORROSION PRODUCT MIXTURES. S. Frederic Marsh, William J. Maeck, and James E. Rein (Phillips Petroleum Co., Idaho Falls, Idaho). Anal. Chem., 34: 1408-11(Oct. 1962).

A procedure is given for the determination of radiomanganese applicable to samples containing fission products and activated stainless steel corrosion products. The method is based on a double precipitation of manganese dioxide, ferric hydroxide scavenging, oxidation to permanganate with silver(II), and precipitation of tetraphenylarsonium permanganate. The stoichiometry and thermal stability of the final precipitate were established. The standard deviation of the method is 1.4%. (auth)

**31560** RAPID DETERMINATION OF ALUMINUM IN MINERALS AND ROCKS BY THERMAL NEUTRON ACTIVATION ANALYSIS. Donald F. Rhodes and William E. Mott (Gulf Research and Development Co., Pittsburgh). Anal. Chem., 34: 1507-8(Oct. 1962).

An activation method for determining Al in minerals and rocks is given which uses thermal neutrons from a Van de Graaff accelerator photoneutron source. In this method, 20 to 40 samples can be analyzed per hour, and there is no interference from fast neutron activation of the other elements found in rocks. The Al contents measurable in this method range from 0.1 to 10%, and the sensitivity can be extended to less than 100 ppm. (D.L.C.)

**31561** THE USE OF GLYOXAL BIS-(2-HYDROXYANIL) IN DETERMINING MICROGRAM AMOUNTS OF URANIUM. A. D. Wilson (Geological Survey and Museum, London). Analyst, 87: 703-6(Sept. 1962).

In alkaline solution, uranium VI readily forms with glyoxal bis-(2-hydroxyanil) a violet complex containing two molecules of reagent to one of uranium; this reaction was made the basis of a method for determining uranium. The complex, soluble in aqueous methanolic solution, has maximum absorption at 575 mμ and is stable in presence of ethylenediaminetetraacetate, which suppresses formation of other metallic complexes. Phosphate and carbonate reduce the sensitivity of the method. (auth)

**31562** DETERMINATION OF RESIDUAL CHLORINE IN CHLORINATED SEA WATER. V. T. Athavale, C. V. Krishnan, and A. R. Subramanian (Atomic Energy Establishment, Trombay, India). Analyst, 87: 707-11(Sept. 1962).

A spectrophotometric method is reported for determining residual chlorine in chlorinated sea water; it is based on the bleaching action of chlorine on methyl orange. Anions such as sulfate, acetate, phosphate, and nitrate do not interfere. Large amounts of weak oxidizing agents, such as ferric iron, cupric copper, and iodine in potassium iodide, do not oxidize the indicator under the given experimental conditions. Hydrogen peroxide, potassium dichromate, and hydrated manganese dioxide react slowly, and bromine and permanganate react in the same way as chlorine. The method does not measure the combined residual chlorine in the absence of bromide ion in the sample. (auth)

**31563** THE DETERMINATION OF URANIUM METAL IN PRODUCTS FROM THE REDUCTION OF URANIUM OXIDES WITH MAGNESIUM. Allan W. Ashbrook (Eldorado Mining and Refining Ltd., Ottawa, Ont.). Analyst, 87: 751-4(Sept. 1962).

A method is outlined for determining U metal in reduction products in order to determine the efficiency of the reduction. The method is based on the dissolution of U metal in bromine–ethyl acetate solution, the back-extraction of the dissolved U by aqueous $Na_2CO_3$ solutions, and then the determination of U by fluorimetric or colorimetric techniques. (D.L.C.)

**31564** THE COMPARISON BETWEEN MEASURED AND CALCULATED VALUES OF GAMMA RAY ABSORPTION ON LEAD NITRATE SOLUTIONS. Z. Kolar and S. Zilic (Univ. of Zagreb). Croat. Chem. Acta, 34: 103-7(1962). (In English)

The method of concentration determination of lead nitrate solutions in the concentration range up to 20 grams per 100 ml by gamma rays absorption measurements was described. $Co^{60}$ and $Cs^{137}$ were used as gamma ray sources. The gamma ray intensities were measured using a scintillation counter. Using a simple equation for the absorption of gamma rays, the equation which contains the directly measured values only, was developed. Using that equation the absorption for all used concentrations was calculated. The agreement between measured and calculated values is fairly good. The possible reason of obtained disagreement is discussed. (auth)

**31565** SPECTROPHOTOMETRIC DETERMINATION OF URANIUM IN THE PRESENCE OF ALKALINE EARTHS. H. Füeredi (Ruder Boskovic Inst., Zagreb). Croat. Chem. Acta, 34: 109-13(1962). (In English)

Hök's method for U determination consists of extraction from $HClO_4$ solution into 8-hydroxyquinoline–$CHCl_3$ and absorbance measurement of the complex at 450 mμ. The effects of Ba, Sr, Ca, and Mg chlorides on Hök's method were investigated and found to be negligible. (D.L.C.)

**31566** STUDIES ON RADIOACTIVATION BY A COBALT-60 γ-RAY SOURCE. V. NONDESTRUCTIVE ANALYSIS BY THE (γ,γ) REACTION. Kenji Yoshihara. Dôitai to Hôshasen, 4: 102-4(Jan. 1962).

Nondestructive analysis of In was studied by means of the $In^{115}(\gamma,\gamma)In^{115m}$ reaction. The samples were irradiated in the interior section of the 10-kc $Co^{60}$ source. The presence of In was indicated clearly, and the γ ray of 0.355 Mev of $In^{115m}$ was measured with ease. This method is also applicable for determining In in alloys. Analysis of 3 In–Sn alloys containing 30, 50, and 70% In, respectively, showed a percentage of error within 3%. (OID)

**31567** SEPARATION OF RARE EARTHS BY COLUMN CHROMATOGRAPHY WITH CELLULOSE POWDER TREATED WITH DI(2-ETHYLHEXYL)ORTHOPHOSPHORIC ACID. PART 2. E. Cerrai, C. Testa, and C. Triulzi (CISE, Milan). Energia nucleare (Milan), 9: 377-84(July 1962). (In English)

The separation of the following lanthanide pairs was obtained by using beds of cellulose powder treated with di(2-ethylhexyl)orthophosphoric acid and HCl as the eluent: La–Ce (2.35); Nd–Pm (2.10); Eu–Gd (1.65); Gd–Tb (3.85) and Tm–Yb (3.33). The value of the separation factor is given in parentheses. Even though such values are quite

different from each other, the value of the average separation factor of two adjacent lanthanides is 2.52 and is in good agreement with that given for liquid-liquid extraction (2.50). Moreover, the following separations are described: Cs–Sr–La–Ce–Nd–Gd–Tb–Tm; Cs–Sr–Y (tracer level) and La–Ce–Nd–Eu (carrier level). The effect of temperature on column efficiency was also studied by considering the separation of Eu–Gd. An increase of operating temperature is very favorable to the resolution of peaks because the kinetic process is appreciably improved even though a slight decrease of the separation factor verifies due to distribution equilibrium reasons. The increase of column efficiency is put into evidence by the related increase of the number of theoretical plates for the given length of the column. (auth)

**31568** EFFUSIOMETRIC DETERMINATION OF DEUTERIUM. P. Duranti Valentini and E. Platone (L.R.S.R., Milan). Energia nucleare (Milan), 9: 400–6(July 1962). (In English)

The determination of deuterium abundance in hydrogen may be performed as an absolute method by means of the measurement of the effusion rate of hydrogen gas through an orifice, provided the fractionation during the effusion process is taken into account. This method can be used for any hydrogenated substance, provided it is possible to convert its hydrogen content into hydrogen gas. (auth)

**31569** ACTIVATION ANALYSIS OF RARE EARTH ELEMENTS. Yü-sheng Yang. Hua Hsüeh Tung Pao, No. 5, 7–9(1961).

An evaluation of the determination of rare earth elements by activation analysis is given. The advantages, disadvantages, and conclusions regarding the type of data obtained are summarized. (P.C.H.)

**31570** RADIOACTIVATION ANALYSIS OF NIOBIUM IN TANTALUM BY IRRADIATION WITH PROTONS IN A CYCLOTRON. I. Tomita (Tokyo Univ.) and H. Saisho. Nature, 195: 1189–90(Sept. 22, 1962).

An activation method is given for determining Nb traces as small as 0.1 ppm in Ta. The method uses the $Nb^{93}$ (p,n) $Mo^{93m}$ reaction at 14.5 Mev, and the $Mo^{93m}$ is separated from Ta by chemical means and its gamma activity counted (D.L.C.)

**31571** NEUTRON DIFFRACTION. J. A. Goedkoop (Reactor Centrum Nederland, Hague). Phillips Tech. Rev., 23: 69–82(1961–62). (In English) (RCN-8)

Neutron diffraction can bring to light certain interesting crystalline structural details that are difficult or impossible to determine by x-ray diffraction. Cases in point are the sites of hydrogen atoms and the orientation of magnetic moments. The technique of neutron diffraction is described and illustrated by giving additional data on the structure of three compounds, already investigated by x-ray diffraction. (auth)

**31572** CHEMICAL IDENTIFICATION OF PHOSPHORUS AND THALLIUM BY QUANTITATIVE NEUTRON ACTIVATION ANALYSIS. E. A. Isaeva, I. E. Makasheva, I. A. Maslov, and A. P. Obukhov. Radiokhimiya, 4: 345–50 (1962). (In Russian)

Determination of P and Tl in various materials by neutron activation was demonstrated using SiO, Si, NaI(Tl), and $LiCl \cdot H_2O$ containing $4 \times 10^{-7}$ to 0.17% P and from $4 \times 10^{-6}$ to 0.1% Tl. (R.V.J.)

**31573** PHOTOMETRIC DETERMINATION OF NEPTUNIUM BY QUERCETIN. E. G. Chudinov and G. N. Yakovlev. Radiokhimiya, 4: 373–5(1962). (In Russian)

It was found that Np(IV) with quercetin (3,5,7,3′, and 4′ pentacoxyflavin) in ethanol-aqueous solution forms a yellow-green complex with maximum absorption at 425 mμ. It was also found that additions of quercetin to acidic Np-ethanol-aqueous solutions with an optical density of 425 mμ achieve a maximum at pH = 1.6. However, in adding Np solutions to quercetin-ethanol-aqueous solutions the optical density reacts very little to the acidity (at pH 3.0 to 7.0). The molar absorption coefficient for the examined Np compounds is 14,000 and 23,000, respectively. (R.V.J.)

**31574** PHOTOMETRIC DETERMINATION OF Np BY THORON. E. G. Chudinov and G. N. Yakovlev. Radiokhimiya, 4: 375–7(1962). (In Russian)

Photometric determination of Np by quercetin is sufficiently sensitive but requires careful Np purification. It was found that tetravalent neptunium with thoron forms a pink complex with a maximum absorption of 545 mμ. A method was developed of Np determination by thoron with preliminary separation of Np by tri-isoactylamine. (R.V.J.)

**31575** SPECTROPHOTOMETRIC DETERMINATION OF NIOBIUM IN CARBONATITES. R. Ya. Epshtein and G. P. Ginberg. Trudy Nauch. Issledovatel. Inst. Geol. Arktiki, Ministerstva Geol. i Ikhrany Nedr S.S.S.R., 119: 84–90(1961).

The determination of Nb in carbonatites having a predominant content of calcite, as well as a high P-content, requires decomposition of the sample in acetic acid. The insoluble, Nb-containing residue is dissolved and the spectrophotometric determination performed by using $NH_4SCN$ as agent. 0.4 g of the rock is heated for 1 hr with 20 ml of 25% acetic acid on a water bath with stirring. The insoluble residue is filtered off, and washed out with 0.5% acetic acid. Filter plus residue are incinerated in a quartz crucible, and the ashes are fused with 1.25–2.5 g $Na_2S_2O_7$ or $K_2S_2O_7$. The melt is dissolved in 12.5–25 ml tartaric acid (15%), the residue filtered off, and the filtrate is diluted with water to 25 or 50 ml. Five ml of a 10% solution of $SnCl_2$ in concentrated HCl and 15 ml of a freshly prepared mixture of 23% solution of $NH_4SCN$ with acetone (1 : 2) are added to 5 ml of the resulting solution. The spectrophotometric determination follows after a period of 30–40 min by using a spectrophotometer at 405 mμ in 1 cm cells, employing the solution of a control test for purposes of comparison. The color is stable for a period of 5 hr. A calibration curve is plotted by using a standard solution of Nb-tartrate + 100 γ/ml of $Nb_2O_5$. The analysis takes half the time of that with tannic acid. (Referativnyy Zhurnal, Khimiya, No. 19, 1961.)

**31576** SULPHONAZO AS A REAGENT FOR THE DETERMINATION OF SCANDIUM. V. G. Brudz, V. I. Titov, E. P. Osiko, D. A. Drapkina, and K. A. Smirnova (All-Union Inst. of Chemical Reagents and All-Union Inst. of Mineral Raw Materials, Moscow). Zhur. Anal. Khim., 17: 568–73(Aug. 1962). (In Russian)

A comparison was made of 14 various reagents which produce a color with scandium ions. The best results in the photometric determination of scandium were obtained with a new sensitive reagent, sulfonazo. A method was developed for the determination of small quantities of scandium in rocks and coal ash using the reagent. (auth)

**31577** SEPARATION OF ZIRCONIUM FROM TITANIUM AND OTHER ELEMENTS BY AN ION EXCHANGE CHROMATOGRAPHIC METHOD. B. I. Nabivanets (Inst. of General and Inorganic Chemistry, Academy of Sciences, Kiev). Zhur. Anal. Khim., 17: 585–90(Aug. 1962). (In Russian)

The absorption of zirconium and titanium from sulfuric

acid solutions was studied depending on the acidity of the medium and on the concentration of sulfate ions. It was established that the optimum value of the separation coefficient is obtained in 0.1 N sulfuric acid. An ion exchange chromatographic method was developed for separating Zr from Ti, V, Fe, Al, Cu, Ni, Co, Zn, Cd, and Be. The method is based on zirconium absorption with the anionite from a 0.1 N $H_2SO_4$ medium; under the above conditions all the other elements pass into the filtrate. (auth)

**31578** DATISCIN — A NEW FLUORIMETRIC REAGENT FOR ZIRCONIUM. A. P. Golovina, I. P. Alimarin, E. A. Bozhevolnov, and L. B. Agasyan (Moscow State Univ. and All-Union Scientific-Research Inst. of Chemical Reagents and Substances of High Parity, Moscow). Zhur. Anal. Khim., 17: 591-4(Aug. 1962). (In Russian)

A new fluorimetric method for the determination of zirconium (from 0.005 to 3 γ of Zr in 1 ml) using datiscin (3-ruthenozide-3,5,7,2′-tetrahydroxy flavone) was worked out. (auth)

**31579** SPECTROPHOTOMETRIC DETERMINATION OF URANIUM BY MEANS OF THIOCYANATE IN THE PRESENCE OF MOLYBDENUM AND VANADIUM. L. M. Moiseeva and Yu. N. Tumanov. Zhur. Anal. Khim., 17: 595-7(Aug. 1962). (In Russian)

Conditions were found for the determination of uranium by the thiocyanate method in aqueous solutions in the presence of small amounts of molybdenum and vanadium. (auth)

**31580** ON THE PROBLEM OF DETERMINATION OF BERYLLIUM IN PHOSPHATE FORM IN THE PRESENCE OF TITANIUM AND OTHER ELEMENTS. P. I. Vasil'yev, R. L. Podval'naya, and A. A. Lavrova. p.19-24 of "Khim., fiz.-khim. i spektr. metody issled. rud redk. i rasseyan. elementov." Moscow, Gosgeoltekhizdat, 1961.

The separation of 30.7 mg BeO with an error of ~1% (relatively) in the presence of $Al_2O_3$, 60 mg $Fe_2O_3$, and 10 mg $Cr_2O_3$ was performed with ammonia, adding 5 ml of 20% $(NH_4)_3PO_4$ solution and 10 ml of 15% solution of trilon B at the first precipitation. The precipitate washed with 2% $NH_4NO_3$ solution was dissolved in HCl, and at the second precipitation 2 ml of phosphate solution and 5 ml of trilon B solution were added. At this stage Ti interferes with the determination of Be. To eliminate the effect of Ti, the solution, after a preliminary neutralization of the excessive acid, was cooled, 5 ml of 20% $(NH_4)_3PO_4$ solution, 15 ml of 15% trilon B solution, and 1 ml of perhydrol are added and the whole is neutralized by methyl red. The separated amorphous residue of Be phosphate was filtered off after 1 hour and, after dissolving, was precipitated again by heating, adding 2 ml of phosphate solution, 7 ml of trilon B solution and 0.5 ml of perhydrol. (Referativnyy Zhurnal, Metallurgiya, No. 2, 1962)

## General Inorganic and Physical Chemistry

*Refer also to abstracts 31363, 31366, 31367, 31376, 31377, 31719, 31720, 31724, 31725, 31732, 31734, 32050, 32052, 32053, 32054, and 32064.*

**31581** (AECL-1573) LATTICE VIBRATIONS IN CRYSTALS WITH THE DIAMOND STRUCTURE. G. Dolling (Atomic Energy of Canada Ltd., Chalk River, Ont.). [1962]. 24p.

A triple axis crystal spectrometer was used to obtain dispersion relations in the [ζ00], [ζζζ], and [0ζζ] directions in a single crystal of silicon, at room temperature. The frequencies for certain [ζ00] direction modes were slightly higher than previous measurements, probably because of improved resolution and calibration. Typical frequencies (units of $10^{12}$ cps) were: TA($\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$), 3.43; TO($\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$), 14.7; O(q = 0), 15.5; AI($\frac{1}{2}$ $\frac{1}{2}$ 0), 6.10; and AII($\frac{1}{2}$ $\frac{1}{2}$ 0), 8.6. Modes AI and AII were neither longitudinal nor transverse, but they were related, respectively, to TA and LA-type modes. The results were analyzed in terms of modified versions of the shell model, proposed originally to describe the dispersion relations in the [ζ00] and [ζζζ] directions in germanium. A substantial improvement between theory and experiment was obtained by the introduction of short range interactions between second nearest neighbor atoms. The shell model analyses for silicon and germanium were extremely similar, and only the results for silicon are presented in detail. (auth)

**31582** (AECL-1575) SPIN WAVES IN MAGNETITE FROM NEUTRON SCATTERING. B. N. Brockhouse and H. Watanabe (Atomic Energy of Canada Ltd., Chalk River, Ont.). [1962]. 24p.

Neutron spectrometric measurements of the acoustical and optical spin waves in magnetite are reported. The complete acoustical branch, and part of an optical branch, were determined for the [100] direction of the reduced zone, principally using the constant Q and constant energy transfer methods. The optical frequency, at which the A and B sublattices precess as units, is 0.058 ev. The results indicate a value for $J_{AB}$ of $2.3 \times 10^{-3}$ ev, with a much smaller (and perhaps ferromagnetic) B-B interaction. The results so far are not very sensitive to the A-A interaction. The acoustic branch decreases in energy with temperature approximately as the magnetization. Difficulties in the experiments largely arise from irreconcilable requirements: that the energy transfers be large because the quantum energies are large, and that the momentum transfers be small in order that the magnetic form factor be of acceptable size. These and other aspects of the experiments are discussed. (auth)

**31583** (AERE-R-4136) THE REACTION OF $UO_3$ AND $U_3O_8$ WITH HYDROGEN FLUORIDE. R. M. Dell, V. J. Wheeler, and J. F. Thain (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Aug. 1962. 12p.

A kinetic study was made of the reaction of hydrogen fluoride with $UO_3$ and $U_3O_8$. The reaction with $UO_3$ is almost independent of temperature in the range 200-450°C, but markedly dependent upon the texture of the $UO_3$. A layer of $UO_2F_2$ is formed on the surface of non-porous particles and subsequent reaction is diffusion controlled. By contrast, porous particles, which possess sufficient voidage to accommodate the crystal volume increase associated with the reaction (~30%), are very reactive, being completely converted to $UO_2F_2$ in a few minutes. The reaction of HF with $U_3O_8$ possesses an activation energy of 5 ± 1 kcal/mole and is not so dependent upon texture. The formation of $2UO_2F_2 + UF_4$ implies that ions at the reaction interface possess appreciable mobility. A speculative mechanism is advanced for this segregation reaction. Some experiments on the rehydrolysis of the product fluorides to uranium oxides are also described. (auth)

**31584** (IS-417) SOME THERMODYNAMIC PROPERTIES OF AQUEOUS RARE-EARTH CHLORIDE SOLUTIONS. David Andrew Csejka and Frank H. Spedding (Ames Lab., Ames, Iowa). Aug. 1961. Contract W-7405-eng-82. 143p.

The heats of dilution of aqueous samarium chloride,

gadolinium chloride, dysprosium chloride, holmium chloride, and thulium chloride solutions were measured at 25°C. Measurements were made with an adiabatically jacketed differential calorimeter having the sensitivity of $3 \times 10^{-4}$ calories per millimeter pen displacement of a recording potentiometer. Samples of concentrations ranging from 0.02 molal to 0.25 molal were diluted and their corresponding heats of dilution were determined to a few thousandths of a calorie. From the heats of dilution it was possible to calculate the following thermodynamic properties: $\overline{P}_1$, the slope of $\phi_L$ versus $m^{\frac{1}{2}}$ in the dilute concentration region; $\phi_L$, the relative apparent molal heat content; $\overline{L}_1$, the relative molal heat content of the solvent and $\overline{L}_2$, the relative molal heat content of the solute. Empirical equations were obtained for these thermal quantities as a function of $m^{\frac{1}{2}}$ from infinite dilution to approximately 0.25 molal. The $\overline{P}_1$ values for all the solutions studied were extrapolated to infinite dilution. In all instances the value at infinite dilution agreed with the Debye-Hückel limiting law values within experimental error. Relative apparent molal heat contents were derived from existing heats of solution data of anhydrous rare-earth chlorides and were compared with the $\phi_L$ values obtained from heat of dilution measurements. (auth)

**31585** (TID-16807) KINETIC STUDY OF THE GASEOUS IODINE-FUSED SILVER NITRATE REACTION. Technical Report No. 1. (thesis). William Herbert Kirby (Ohio State Univ. Research Foundation, Columbus). [nd.] Contract AT(11-1)-750. 76p.

A study was made of the reaction between gaseous $I_2$ and molten silver nitrate at 215°C and 151°C using radioactive $I^{131}$ as a tracer to continuously monitor the system. The data are correlated by a mechanism in which gaseous $I_2$ diffuses to the liquid-gas interface, reacts, and the molten products diffuse into the bulk of the liquid. It is assumed that both gas and liquid phases are well mixed and resistance to diffusion is in the films on both sides of the interface. The value of the overall transfer coefficient varies from $2.16 \times 10^{-6}$ to $4.75 \times 10^{-5}$ (gm moles/sec $cm^2$ atm) for bed thicknesses varying from 0.507 to 0.127 cm. This mechanism holds for 50% conversion or greater depending on bed thickness and temperature. The remainder of the reaction is much slower and is believed dependent on the diffusion of reacted products through the main body of liquid in which a concentration gradient was established. This is explained by an increase in viscosity of the reaction mixture with an increase in concentration of products and poorer mixing. A method for the gravimetric analysis of the fused mixture $AgNO_3$-AgI-$AgIO_3$ based on the relative solubilities of the salts in water and ammonia hydroxide was used to analyze the reaction products. A differential grinding and radioactive counting technique was used to determine concentration profiles in the reacted solids. Preliminary data are presented on the solid-liquid phase diagram of the aforementioned three-component system. (auth)

**31586** (UCRL-10397) A METHOD FOR ESTIMATING THE HEAT OF FORMATION AND FREE ENERGY OF FORMATION OF INORGANIC COMPOUNDS (thesis). Darrell E. Wilcox (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 1, 1962. Contract W-7405-eng-48. 123p.

A general method of independently estimating the heat of formation, $\Delta H_f^0$, and free energy of formation, $\Delta F_f^0$, of inorganic compounds was developed. The result is a simple equation involving three parameters characteristic of each ion. Each valence state of an element may be assigned a value for each of the parameters. The parameters may be evaluated for any ion if at least three experimental heats of formation or free energies of formation are known. The equation was applied to the correlation of known $\Delta H_f^0$ data for 34 monovalent and divalent cations and 32 anions, including the metallic halides, oxides, sulfides, and compounds such as the sulfates, carbonates, and tungstates. The average deviation obtained for 427 compounds was 1.98 kcal/mole, and the maximum deviation was 8.73 kcal/mole. Similar results were obtained in a correlation of $\Delta H_f^0$ for a set of trivalent and tetravalent cations, and in the correlation of $\Delta F_f^0$ of many of the same compounds. An error of less than 15 kcal/mole may generally be expected in estimating an unknown if parameters evaluated from three or more experimental data are used. (auth)

**31587** (AEC-tr-5352) CONTRIBUTIONS TO THE THEORY OF THORIUM SALT MANUFACTURE. I. THE SULFATE PURIFICATION METHOD. I. Koppel and H. Holtkamp. Translated for Oak Ridge National Lab., Tenn., from Z. Anorg. Chem., 67: 266-92(1910). 64p. (Includes original, 27p.).

Studies were made of the preparation of thorium nitrates by the sulfate purification process. Solubility determinations of thorium sulfate octahydrate were conducted in acids of different concentrations. The rate at which thorium sulfate crystallizes from supersaturated solutions was determined. A mathematical check was made of the solubility determinations. (M.C.G.)

**31588** (AEC-tr-5394) THE VISCOSITY AND EFFECTIVE MOLECULAR DIAMETER OF FLUORINE. E. U. Franck and W. Stober. Translated by S. Katz (Oak Ridge Gaseous Diffusion Plant, Tenn.) from Z. Naturforsch., 7a: 822-3(1952). 4p.

The viscosity of gaseous fluorine was measured from 90 to 471°K by the oscillating disc method. Data on molecular diameter and viscosity for fluorine and its neighbors are tabulated. The d-values fit the series $\sigma'$ the critical data ($d_{kr}$) and also confirm the polarization value. The fluorine molecule regarding the sphere of action is near nitrogen and oxygen but much smaller than chlorine. Of the previously measured multi-atomic gases only hydrogen has a smaller low-velocity collision diameter. (P.C.H.)

**31589** (CEA-tr-A-1114) ECHANGE ISOTOPIQUE ENTRE L'HYDROGÈNE ET L'AMMONIAC LIQUIDE EN PRÉSENCE DE CATALYSEURS EN PLATINE. (Isotopic Exchange Between Hydrogen and Liquid Ammonia in the Presence of Platinum Catalysts). R. Haul and D. Blennemann. Translated into French from Naturwissenschaften, 48: 644(1961). 7p.

The isotopic exchange between hydrogen and liquid ammonia in the presence of Pt catalysts was studied at temperatures between −70°C to 25°C and at H pressures up to 150 atm. A linear increase of the number of atoms exchanged per unit of time was found as a function of the quantity of catalyst. The exchange velocity increases proportionally with the square root of the H pressure. A comparison was made between a heterogeneous catalyst in the gaseous phase and in the liquid phase. It was shown that the exchange mechanisms in the liquid and gaseous phases are basically the same. The exchange velocity is much lower in the liquid phase than in the gaseous phase. (J.S.R.)

**31590** (CEA-tr-A-1135) SÉPARATION DU STRONTIUM ET DU CALCIUM PAR PRÉCIPITATION SÉLECTIVE DU SULFATE DE STRONTIUM. (Separation of Strontium and Calcium by Selective Precipitation of Strontium Sulfate). L. Berak and J. Munich. Translated into French from Collect. czechosl. chem. Communs., 26: 276-81(1961). 15p.

A new procedure for separating Sr and Ca, based on the precipitation of strontium sulfate after displacement of the

strontium chelates by magnesium sulfate, was perfected. (tr-auth)

**31591** (CEA-tr-R-1492) DIFFUSION THERMIQUE. A. M. Rozen (Rosen). Translated into French from p.124-48 of "Thermal Diffusion" (a publication of Atomizdat, Moscow, 1960). 71p.

A theoretical study of thermal diffusion was made with a consideration of a number of factors. Topics considered were separation coefficients, thermal diffusion columns, flow rates, mass transfer, variations of the height-unit transfer as a function of temperature and pressure, cylinder geometry, conditions for the stabilization of the diffusion and heat, effect of turbulence, and thermal diffusion in liquids. (J.S.R.)

**31592** (CEA-tr-R-1593) CHIMIE DU LITHIUM ET DE SES COMPOSÉS. CHAPITRE II. PROPRIÉTÉS PHYSICO-CHIMIQUES DU LITHIUM. (Chemistry of Lithium and Its Compounds. Chapter II. Physico-chemical Properties of Lithium). Translated into French from p.34-74 of "Lithium, Its Chemistry, Its Technology," Moscow. [nd]. 96p.

The physical and chemical properties of lithium are described as an introduction to a discussion of the properties of lithium compounds. The lithium compounds considered are those with hydrogen, oxygen, nitrogen, carbon, halogens, sulfur, phosphorus, and silicon. 128 references. (J.S.R.)

**31593** (NP-tr-884) ÜBER DIE THERMODYNAMISCHEN EIGENSCHAFTEN DES KOHLENDIOXYDS. (On the Thermodynamic Properties of Carbon Dioxide). P. M. Vukalovič and V. V. Altunin. Translated into German from Teploenergetika, 8: No. 11, 73-9(1961). 23p.

The results of experimental studies on the p-v-t dependence of $CO_2$ were represented in tabular form as function of volume, entropy, and enthalpy in the temperature interval from 200 to 500°C at pressures from 1 to 300 atm. The tabular values were compared with the data of other investigators. (tr-auth)

**31594** ISOTOPIC EXCHANGE OF HYDROGEN IN THE TRIFLUOROACETIC ACID ESTERS. 1. THE HYDROGEN EXCHANGE OF ALKYL TRIFLUOROACETATES WITH TRIFLUOROACETIC ACID. V. N. Setkina, D. N. Kursanov, and E. V. Bykova (Inst. of Organic Compounds, Academy of Sciences, USSR). Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk, No. 8, 1367-72(Aug. 1962). (In Russian)

The kinetics of the reaction, recently uncovered (Izvest. Akad. Nauk, Otdel. Khim. Nauk, 378(1961)), on the isotopic exchange of the H of trifluoro acetates with deuterium-enriched water-free trifluoroacetic acid, was further examined, studying the corresponding reaction of alkyl trifluoro acetates. It was found that in ternary compounds the H–D exchange takes place with a relatively high rate but it is inhibited in the secondary and primary esters. The exchange reaction of the ternary esters is further enhanced by increasing the acidity of the system by the addition of trifluoro acetic acid dissolved in sulfuric acid; even this addition was not able to cause a noticeable reaction in the primary esters. It is assumed that the exchange reaction is due to the ionization of the esters and the formation of carbonium ions which are capable to participate in the exchange. (TTT)

**31595** INTERFACE REACTIONS BETWEEN METALS AND CERAMICS: II. REFRACTORY METALS—FUSED $SiO_2$ SYSTEM. W. M. Armstrong, A. C. D. Chaklader, and M. L. A. De Cleene (Univ. of British Columbia, Vancouver). J. Am. Ceram. Soc., 45: 407-12(Sept. 1962).

In a study of the interfacial reactions between $SiO_2$ and the refractory metals Ta, Nb, V, and Mo, a wide range of reactions was observed. Investigation of normal and tapered sections at the interface showed considerable reaction and solution in the case of V, reactions in the cases of Ta and Nb, and very little reaction in the case of Mo. The major interfacial reaction was oxygen corrosion followed by (most possibly) reaction with silica glass to form silicates. X-ray data showed that the oxides were the principal components at the interface. Evidence was obtained for the formation of silicides in the case of the system $Ta-SiO_2$. A very low melting silicate was formed in the case of V and silica. (auth)

**31596** THE SYSTEM $La_2O_3-TiO_2$; PHASE EQUILIBRIA AND ELECTRICAL PROPERTIES. J. B. MacChesney and H. A. Sauer (Bell Telephone Labs., Inc., Murray Hill, N. J.). J. Am. Ceram. Soc., 45: 416-22 (Sept. 1962).

Phase relations at liquidus temperatures in the system $La_2O_3-TiO_2$ were studied in air. The existence of two previously unreported compounds, $La_2O_3 \cdot TiO_2$ and $2La_2O_3 \cdot 9TiO_2$, is postulated on the basis of x-ray and microscopic examination of crystalline samples, and in the case of $La_2O_3 \cdot TiO_2$, on a maximum in the liquidus curve at that composition. Quenched liquids of the primaryphase field of rutile were found to be semiconducting. This property was related to oxygen loss from both liquid and crystalline phases and is discussed in the light of weight loss experiments, microscopic examination of quenched samples, and information obtained from the literature. Dielectric constant and loss factor of the compounds $La_2O_3 \cdot TiO_2$, $La_2O_3 \cdot 2TiO_2$, and $2La_2O_3 \cdot 9TiO_2$ are reported at 1 Mc over the temperature range 25 to 500°C. (auth)

**31597** THE CHEMISORPTION OF HYDROGEN SULFIDE, METHYL SULFIDE, AND CYCLOHEXENE ON SUPPORTED NICKEL CATALYSTS. I. E. Den Besten and P. W. Selwood (Northwestern Univ., Evanston, Ill.). J. Catalysis, 1: 93-102(May 1962).

Magnetization measurements on supported nickel catalysts showed that hydrogen sulfide is dissociatively chemisorbed, forming four chemisorptive bonds with the nickel surface. This is confirmed by deuterium exchange results. The mechanism of chemisorption of methyl sulfide is strongly temperature dependent. It is associatively adsorbed at room temperature forming two chemisorptive bonds, but at higher temperatures extensive C—H and C—S bond rupture occurs. Cyclohexene is dissociatively chemisorbed at 25°C, forming two adsorbed hydrogen atoms and a diadsorbed $C_6H_8$ radical. This conclusion is confirmed by deuterium exchange experiments. (auth)

**31598** STUDY ON THE FORMATION MECHANISM OF METHANE BY HYDROCRACKING IN THE FISCHER-TROPSCH SYNTHESIS. Herbert Koelbel, Hans-Bolko Ludwig, and Hans Hammer (Technische Universität, Berlin). J. Catalysis, 1: 156-64(May 1962).

The question was studied whether the methane formed in great quantities during the hydrogenation of carbon monoxide with hydrogen in the Fischer-Tropsch synthesis may be generated by catalytic hydrocracking of primarily formed higher molecular weight hydrocarbons. The studies were conducted with precipitated Co, Fe, and Ni carrier-type catalysts using $C^{14}$ labeled compounds. It was shown that under normal synthesis conditions with Co and Ni catalysts the percentage of methane formed by catalytical hydrocracking of primarily obtained hydrocarbons related to the total methane formed is only about 5%. The corresponding value for Fe catalysts is below 3%. Above 204°C with Ni catalysts and above 213°C with Co catalysts noticeable in-

crease of the formation of methane by hydrocracking reactions was observed, the percentage of cracking methane for synthesis with Fe catalysts being largely independent of temperature. (auth)

**31599** THE INFRARED SPECTRUM OF HYDROGEN CHEMISORBED ON ZINC OXIDE. R. P. Eischens, W. A. Pliskin, and M. J. D. Low (Texaco Research Center, Beacon, N. Y.). J. Catalysis, 1: 180-91(May 1962).

Chemisorption of hydrogen on pure zinc oxide at 30°C produces bands at 2.86 and 5.85 μ which are attributed to oxygen–hydrogen and zinc–hydrogen stretching vibrations. The ratio of the intensities of these bands remains constant as the intensities of both bands increase with increasing hydrogen pressure up to 4 cm. Above a pressure of 4 cm, an excess of loosely bonded OH is observed. In addition to the covalent chemisorption which produces OH and ZnH bands, there is a slow chemisorption at 30°C which does not produce detectable infrared bands. This slow chemisorption is attributed to $H^+$. When the zinc oxide is heated above 80°C in hydrogen at constant pressure both bands decrease while again maintaining a constant ratio between OH and ZnH intensities. Above 80°C an increase in the electrical conductivity is indicated by a decrease in the background transmission. It is concluded that the irreversible change in conductivity is due to reduction of the zinc oxide. It is also concluded that the high temperature maximum which is commonly observed for hydrogen–zinc oxide isobars is not due to formation of an OH species. (auth)

**31600** ON THE ENERGETIC HETEROGENEITY OF CLEAN EVAPORATED NICKEL FILMS STUDIED BY MEANS OF THE PLACE CHANGE BETWEEN ADSORBED ISOTOPIC CO MOLECULES. R. Suhrmann, Hj. Heyne, and G. Wedler (Technische Hochschule, Hanover). J. Catalysis, 1: 208-15(June 1962).

The adsorption of $C^{12}O^{16}$, $C^{13}O^{16}$, and $C^{12}O^{18}$ was used to study the energetic surface heterogeneity of evaporated Ni films. The isotopic gases were adsorbed one after the other and the gas phase was analyzed mass spectrometrically. If the gases were adsorbed at 77°K, the equilibrium between gas phase and adsorption phase was obtained between 90 and 195°K. The temperature at which the equilibrium is reached is lowest for the molecules adsorbed at high coverages and highest for the molecules adsorbed on the clean film indicating differences in adsorption energies of the film surface concerning the adsorption of CO. If the successive adsorption of the three isotopic gases took place at 273°K, no difference in the behavior of the isotopic gases could be observed, indicating that the mobility of the adsorbed molecules is large enough to overshadow the influence of surface heterogeneity. An isotopic exchange between the atoms of the adsorbed molecules could not be observed. (auth)

**31601** THE CATALYTIC EXCHANGE WITH DEUTERIUM OF POLYMETHYLCYCLOPENTANES ON METAL FILMS. EVIDENCE FOR π-BONDED INTERMEDIATES. F. G. Gault, J. J. Rooney, and C. Kemball (Queen's Univ., Belfast). J. Catalysis, 1: 255-74(June 1962).

A new mechanistic theory was developed to explain several reactions of hydrocarbons on metal catalysts. Interconversion can take place on the surface not only between σ-bonded monoadsorbed and diadsorbed intermediates but also between π-bonded species provided that the reactant hydrocarbons contain three or more adjacent nonquaternary carbon atoms. Evidence for this theory was obtained by the catalytic exchange with deuterium of several polymethylcyclopentanes on films of rhodium, palladium, platinum, and nickel, using a mass-spectrometric analytical technique. Studies on cis-trans isomerization, followed by gas-liquid chromatography, provided further support for the theory. Palladium gave the most striking evidence for π-bonded intermediates. Rhodium was the most active metal for the exchange reactions and at low temperatures the role of σ-bonded intermediates was much greater than that of the π-bonded which only participated in the reactions at higher temperatures comparable to those needed to bring about exchange on palladium. The behavior of nickel and platinum was intermediate between that of rhodium and palladium. Evidence is presented to show that on rhodium and nickel αα-diadsorbed intermediates permit the exchange process to propagate from the hydrogens on one side of cyclopentane rings to those on the other side. Platinum can cause exchange by αγ-diadsorbed intermediates at the same temperatures as required to form π-bonded species. Explanations are given for some apparently anomalous features of the distributions of deuterocompounds formed on rhodium. The application of the theory to several aspects of the reactions of hydrocarbons on metal catalysts is discussed. (auth)

**31602** HEAT OF FORMATION OF BERYLLIUM CHLORIDE. C. J. Thompson, G. C. Sinke, and D. R. Stull (Dow Chemical Co., Midland, Mich.). J. Chem. Eng. Data, 7: 380-1(July 1962).

The heats of solution of Be metal and $BeCl_2$ in HCl solution were measured to be −89.62 and −45.92 kcal/mole for (8.381 HCl + 67.982 $H_2O$), respectively. From these values, the heat of formation for $BeCl_2$ was calculated to be −118.25 ± 0.50 kcal/mole which agrees with the value measured by direct reaction of Be and $Cl_2$ (−188.03 ± 0.56 kcal/mole). (D.L.C.)

**31603** HEAT OF FUSION OF $3LiF \cdot ThF_4$. Robert A. Gilbert (Oak Ridge National Lab., Tenn.). J. Chem. Eng. Data, 7: 388-9(July 1962).

The heat fusion of $3LiF \cdot ThF_4$ was determined from calorimetric measurements to be 13,960 ± 50 cal/mole, and the melting point was found to be 568.4°C. (D.L.C.)

**31604** IDEAL GAS THERMODYNAMIC FUNCTIONS OF SOME SELECTED ELEMENTS. D. E. Poland, J. W. Green, and J. L. Margrave (Univ. of Wisconsin, Madison). J. Chem. Eng. Data, 7: 389-90(July 1962).

Tables are presented for the free-energy functions $(-(F_T^\circ - H_0^\circ)/T)$ and enthalpy functions $((H_T^\circ - H_0^\circ)/T)$ of the elements Tc, Ru, Te, I, Hf, Tl, Pb, Bi, Po, Rn, Ra, Ac, and Th at 200 to 7000°K. (D.L.C.)

**31605** CRYSTAL STRUCTURE OF $CsMnF_3$. Allan Zalkin, Kenneth Lee, and David H. Templeton (Univ. of California, Berkeley). J. Chem. Phys., 37: 697-9(Aug. 15, 1962).

A single-crystal x-ray diffraction study shows that $CsMnF_3$ has the hexagonal $BaTiO_3$-type structure. The space group is $P6_3/mmc$. The unit cell with a = 6.213 Å, c = 15.074 Å contains six formula units. Each cesium atom has 12 fluorine neighbors at an average distance of 3.13 Å. One third of the manganese atoms occupy the centers of fluorine octahedra that share their corners with other octahedra as in the perovskite structure. The remaining two thirds of the manganese atoms are in distorted fluorine octahedra that each share one face and three corners with other octahedra; these manganese atoms are in pairs 3.00 Å apart. The average Mn-F distance in the octahedra is 2.13 Å. (auth)

**31606** EFFECT OF INERT SALTS ON EQUILIBRIUM AND RARE CONSTANTS FOR IONIC REACTIONS. J. W.

Gryder (Johns Hopkins Univ., Baltimore). J. Chem. Phys., 37: 718-22(Aug. 15, 1962).

Empirical evidence is given to show that individual ion activity coefficients can be written as $\log\gamma_t = Z_t^2 G(S) + [\nu_1\alpha_{1t} + \nu_2\alpha_{2t}]C$, where $\nu_1$ and $\nu_2$ are the number of ions of type 1 and 2 formed from one formula of the supporting electrolyte, C is the formal concentration of the electrolyte, $Z_t$ is the charge of the ion $t$, G(S) is a function of the medium only, $\alpha_{1t}$ is a function of the ion-size parameter for ions 1 and $t$, and $\alpha_{2t}$ is a similar function of the ions 2 and $t$. The equation is applicable only if the concentration of ion $t$ is small in comparison to the concentration of electrolyte. Mayer's theory predicts that the above equation, when used to calculate experimentally observable quantities, should be correct to within good accuracy for ion-size parameters between 5.5 and 8.5 Å in a 1-1 supporting electrolyte and for higher-charged electrolytes at ionic strengths above about 0.2. Using this equation one can calculate the ratio of the rate constant for the bromacetate–thiosulfate reaction to that for the peroxydisulfate–iodide reaction at infinite dilution from data obtained in $MgSO_4$, $Mg(NO_3)_2$, $Na_2SO_4$, and $NaNO_3$ solutions at concentrations between 0.25 and 2F. The value obtained under these conditions is within experimental accuracy of the value obtained by extrapolation to infinite dilution from ionic strengths below 0.02. (auth)

**31607** THE EFFECT OF ELECTROLYTE COMPOSITION ON THE ANODIC OXIDATION OF ZIRCONIUM. N. J. M. Wilkins (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Electrochem. Soc., 109: 998-9 (Oct. 1962).

The color/weight gain relations of anodic films on Zr were found to be the same for three different electrolytes (0.2 N $H_2SO_4$, saturated ammonium borate, and 1% KOH), indicating that the color is a measure of the film thickness. On the other hand, the weight gain/voltage relation varies with the electrolyte. Experiments were conducted in which Zr specimens were transferred from 0.2 N $H_2SO_4$ to 1% KOH or vice versa. In all transfers, the slope of the weight gain vs voltage curve changed from that characteristic of the first electrolyte to that of the second electrolyte. In the case of transfer from $H_2SO_4$ to KOH, the slope was abnormally large, indicating that changes were taking place in the first-formed part of the film. (D.L.C.)

**31608** A RADIOTRACER STUDY OF ANODIC OXIDATION. J. A. Davies, J. P. S. Pringle, R. L. Graham, and F. Brown (Atomic Energy of Canada Ltd., Chalk River, Ont.). J. Electrochem. Soc., 109: 999-1001(Oct. 1962).

Studies using $Xe^{125}$ tracers were conducted to determine the mobile species in anodic oxidation of Al and Ta. Specimens of Al and Ta were bombarded with 5-kev $Xe^{125}$ ions to form layers of $Xe^{125}$ below the surfaces, and the energy distribution of the conversion electrons coming from the surfaces was used as an indication of the depth of the $Xe^{125}$ layers. The bombarded specimens were then anodized at constant current in aqueous 3% ammonium citrate. The $Xe^{125}$ layer in Al was found to remain at the same depth near the surface, indicating that the film grows mainly by oxygen migration, although metal migration probably also occurs. In Ta, the $Xe^{125}$ layer moves to deeper depths but remains at the middle of the oxide film, indicating that both oxygen and metal migrations contribute to the oxide film growth. (D.L.C.)

**31609** INFRA-RED ABSORPTION OF WATER OF HYDRATION IN LANTHANIDE TRICHLORIDES. R. J. Morrow and A. Palm (Univ. of California, Livermore and Berkeley). J. Inorg. & Nuclear Chem., 24: 239-44(Mar. 1962). (UCRL-6564-T). (In English)

The absorption spectra of the hydrated lanthanide trichlorides were examined in the region between 4000–400 $cm^{-1}$ by the KBr disk technique. The major bands are assigned to vibrations characteristic of the water molecules on the basis of the consistent pattern of the observed spectra, and isotopic frequency shifts upon deuteration. (auth)

**31610** INFRA-RED SPECTRA OF NITRATE SALTS IN TRIBUTYL PHOSPHATE SOLUTION. L. I. Katzin (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Inorg. & Nuclear Chem., 24: 245-56(Mar. 1962). (AERE-R-3031). (In English)

The infrared spectra of some sixteen nitrates were observed in tributyl phosphate solvent. The splitting of the $\nu_3$ band of the nitrate ion is followed in particular. The findings are shown to be consistent with the concept that in general in these solutions a co-ordinate bond is formed between the anion and the metallic cation. The exceptions are pointed out, and it is established that a splitting of about 100 $cm^{-1}$ serves as a defensible division between essentially electrostatic splitting (lower) and splitting due to co-ordinate binding (higher). The correlation between the tributyl phosphate spectra and the vibrational spectra in the solid crystals is pointed out, and with it the apparent fact that even in the conventionally ionic crystals the interaction with the cation is sufficient to modify the vibrational pattern to that of the co-ordinately bound ligand. (auth)

**31611** PREPARATION AND PROPERTIES OF THE SINGLE CRYSTALLINE $AB_2$-TYPE SELENIDES AND TELLURIDES OF NIOBIUM, TANTALUM, MOLYBDENUM AND TUNGSTEN. L. H. Brixner (E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.). J. Inorg. & Nuclear Chem., 24: 257-63(Mar. 1962). (In English)

The $AB_2$-type selenides and tellurides of niobium, tantalum, molybdenum, and tungsten were prepared in single crystalline form by means of transport reactions. Lattice parameters were determined on the basis of single crystal patterns and are given for the eight compounds. Pertinent thermoelectric parameters, such as electrical resistivity, Seebeck coefficient, and thermal conductivity were measured on compacted polycrystalline aggregates and are given together with the calculated Figure of Merit. (auth)

**31612** COMPLEXES OF URANYL ION WITH SOME SIMPLE ORGANIC ACIDS. C. A. Crutchfield, Jr., W. M. McNabb, and J. F. Hazel (Univ. of Pennsylvania, Philadelphia). J. Inorg. & Nuclear Chem., 24: 291-8(Mar. 1962). (In English)

Stepwise formation constants were determined for complexes of uranyl ion with lactic, $\beta$–OH–propionic, $\alpha$–OH–butyric, and $\beta$–OH–butyric acids. The constants were determined by pH titration, and some qualitative information was also obtained by polarography. (auth)

**31613** ON THE URANATES OF AMMONIUM. I. THE TERNARY SYSTEM $NH_3$–$UO_3$–$H_2O$. E. H. P. Cordfunke (Reactor Centre of the Netherlands (R.C.N.), Petten). J. Inorg. & Nuclear Chem., 24: 303-7(Mar. 1962). (In English)

The ternary system $NH_3$–$UO_3$–$H_2O$ was studied in aqueous solutions. From chemical and x-ray analysis four compounds, having the bruto-formulas: $UO_3 \cdot 2\ H_2O$, $3\ UO_3 \cdot NH_3 \cdot 5\ H_2O$, $2\ UO_3 \cdot NH_3 \cdot 3\ H_2O$, and $3\ UO_3 \cdot 2\ NH_3 \cdot 4\ H_2O$ were found to exist in the system at 40°C. The stability of the phases is discussed. The reaction of a solution of uranylnitrate with ammonia was also studied. The precipitates thus formed could be identified as I(pH = 3.5), II(pH = 4–7) and III(pH > 7). However, they cannot be isolated in a pure form, owing to the presence of nitrate, which cannot be removed completely by washing with water. (auth)

**31614** THE PHYSICAL INTERACTION BETWEEN LIQUID PHASES OF METAL AND WATER. Tadeusz Nowinski. Ochrona Pracy, 16: 8-14(1961).

Investigations were made on liquid metal dropping from a crucible, a jet of liquid metal striking water, liquid metal immersed in water, liquid metal solidifying on the bottom of a water tank, and explosions of differing intensities. A total of 880 tests were made with aluminum alloy and a few with magnesium alloy. Explosions occur when liquid metal at a temperature of 700-900°C penetrates to the bottom of a tank with the depth of water less than 25 cm and temperature below 50°C. Of importance is the relationship between the rate of flow of the liquid metal particles and the size of the hole through which the metal pours, as also is the height of the hole above the water surface. The special concept of kinematic defect of mass concentration is introduced. A protective layer of oil or of bituminous base paint on the bottom and walls of the tank protects against the formation of a steam cushion which promotes explosion. (Referativnyy Zhurnal, Electroteknika i energetika, No. 5, 1962)

**31615** DECOMPOSITION OF CALCIUM ZIRCONATE IN THE PRESENCE OF SOME OXIDES DURING HEATING. E. K. Keler and A. B. Andreeva. Ogeupory, No. 12, 581-6 (1961).

The thermal resistivity of calcium zirconate as a refractory material was investigated in the presence of the oxides of elements of the fourth group and alumina. For the synthesis of calcium zirconate at 1350, 1500, and 1600°C, industrial zirconium dioxide with a content of 98.4% $ZrO_2$ and calcium carbonate, as well as $ZrO_2$, $TiO_2$, $SiO_2$, $ThO_2$, and $Al_2O_3$ were used. Specimens from calcium zirconate react at 1350°C in contact with silica and titanium dioxide. Up to 1450°C the reaction did not take place with zirconium dioxide, thorium dioxide, and alumina. Calcium zirconate in an equimolecular mixture with $ZrO_2$, $SiO_2$, $TiO_2$, and $Al_2O_3$ decomposed during heating up to 1500°C: with $SiO_2$ into calcium silicate and monoclinic zirconium dioxide; with $ZrO_2$ into the solid solution $ZrO_2-CaO$ and some undecomposed zirconate is left; with $Al_2O_3$ into the solid solution $ZrO_2-CaO$ and calcium aluminate; and with $TiO_2$ into the triple compound $ZrO_2 \cdot CaO \cdot 2TiO_2$ and a residue of $CaZrO_3$. With $ThO_2$, calcium zirconate did not decompose during heating to 1600°C. (OTS)

**31616** THERMAL CONDUCTIVITY OF YTTRIUM IRON GARNET. B. Luethi (Univ. of Chicago). Phys. and Chem. Solids, 23: 35-8(Jan.-Feb. 1962). (In English)

The low temperature thermal conductivity of yttrium iron garnet was measured. It showed the following features: a quadratic temperature dependence at liquid helium temperatures, a decrease in conductivity with an applied magnetic field in the same temperature region, which became more pronounced with decreasing temperature but which was not observed at liquid hydrogen temperature and, finally, a slight increase in conductivity with an applied longitudinal field of approximately 300 G. All the features can be understood, assuming that the main contribution to the thermal conductivity in this temperature region comes from spin waves rather than phonons. (auth)

**31617** THE EFFECT OF COLOR CENTERS ON THE NUCLEAR SPIN-LATTICE RELAXATION TIME IN LITHIUM FLUORIDE. B. Josephson, Jr. and M. W. P. Strandberg (Massachusetts Inst. of Tech., Cambridge). Phys. and Chem. Solids, 23: 67-73(Jan.-Feb. 1962). (In English)

The dependence of the spin-lattice relaxation time of fluorine nuclei in lithium fluoride on the concentration of radioinduced color centers was investigated under rigidly controlled conditions. F-center concentrations were determined from ultraviolet absorption spectra. The data agree with the theoretical predictions for diffusion-limited relaxation, with respect to the dependence on both the concentration of color centers and the diffusion constant for nuclear-spin diffusion. Some linewidth measurements were made for the fluorine resonance; data were obtained with the [110] crystalline axis parallel to the dc magnetic field. (auth)

**31618** VIRIAL THEOREM AND COHESIVE ENERGIES OF SOLIDS, PARTICULARLY IONIC CRYSTALS. A. Froeman (Uppsala Univ.) and Per-Olov Loewdin. Phys. and Chem. Solids, 23: 75-84(Jan.-Feb. 1962). (In English)

The importance of the virial theorem for the cohesive energies of solids is discussed. An interpretation of the cohesive energy independent of any particular model is proposed, taking into account the increase in the kinetic energy which follows when a compound is formed. The empirical cohesive energies of the alkali halides obtained from the Born-Haber cycle are used in making this interpretation, and a comparison is made with alternative interpretations. The quantum mechanical treatment of the cohesive energy is also discussed. It is shown that the analytic subtraction procedure frequently used in calculating the cohesive energy and leading to the identical cancellation of the large energy terms connected with the free constituents can be combined with Hylleraas scaling technique which makes it possible to get the virial theorem for the compound as well as for the free constituents satisfied. In the one-electron scheme applied to the alkali halides, the Landshoff identity cannot be used, and it is necessary to calculate the changes in the kinetic and potential energies separately. A detailed numerical study was carried out for LiCl. (auth)

**31619** LOWEST VALENCE-ELECTRON ENERGY BAND AND KNIGHT SHIFT IN BERYLLIUM. V. E. Wood and F. J. Milford (Battelle Memorial Inst., Columbus, Ohio). Phys. and Chem. Solids, 23: 160-1(Jan.-Feb. 1962). (In English)

Results of a recalculation of an approximate lowest valence-electron energy band for metallic beryllium and a consequent revision of a theoretical estimate of the Knight shift are reported. The correct shape of the lowest valence-electron energy band in Be is fairly close to a parabola, with an average effective mass ratio over the band of about 0.793. The effective mass ratio at the bottom of the band is about 0.75. The ground state energy is -1.032 ry and the cohesive energy is 52.1 kcal/mole. Calculation of the Knight shift is also discussed. (P.C.H.)

**31620** NUCLEAR MAGNETIC RESONANCE SHIFTS IN RARE EARTH NITRIDES. R. G. Shulman and B. J. Wyluda (Bell Telephone Labs., Murray Hill, N. J.). Phys. and Chem. Solids, 23: 166(Jan.-Feb. 1962). (In English)

Nuclear magnetic resonance measurements on the $N^{14}$ nucleus in TbN are reported. In TbN, the $N^{14}$ resonance is shifted to higher fields. The shifts measured from the line center to the undisplaced position (the reference was liquid $N_2$) were $(\Delta H/H_0)_{77} = 0.074$ and $(\Delta H/H_0)_{300} = 0.026$. The shifts increased as the temperature was lowered and, within the large limits of error that existed, they followed the expected susceptibilities. It appears that the shifts come from an induced hyperfine interaction which ultimately arises from the unpaired 4f electrons. Smaller positive shifts were observed in TmN of $(\Delta H/H_0)_{77} = 0.012$ and $(\Delta H/H_0)_{300} = 0.004$, but the magnetic properties of the compound were not known. (P.C.H.)

**31621** A NOTE ON SPECIFIC HEAT ANOMALIES IN THE Pd/H AND Pd/D SYSTEMS. F. A. Lewis (Queen's Univ. of Belfast). Phys. and Chem. Solids, 23: 171-2 (Jan.-Feb. 1962). (In English)

Discussion is given on the specific heat anomalies in Pd/D and Pd/H systems. It is pointed out that the anomalies occur over ranges of temperature close to those where maxima appear in the rotational specific heat curves of equilibrium mixtures of ortho- and para-hydrogen and deuterium. Similarities in the form of the respective specific heat curves may be pure coincidence, but the argument is advanced that they are associated with fairly strong bonding in the solids, at low temperatures, between pairs of absorbed hydrogen and deuterium atoms. (P.C.H.)

**31622** THE INFLUENCE OF VIBRATION-ROTATION INTERACTION ON INTENSITIES IN THE ELECTRONIC SPECTRA OF DIATOMIC MOLECULES. II. THE SILVER HYDRIDE MOLECULE. R. C. M. Learner (Imperial Coll. of Science and Tech., London). Proc. Roy. Soc. (London), A, 269: 327-37(Sept. 25, 1962).

The highly perturbed spectra of the $A^1\Sigma - X^1\Sigma$ systems of the silver hydride and deuteride molecules are explained in terms of an anomalous rotationless potential curve for the A state. While this curve explains the irregularity of the vibrational interval, it is necessary to include a rotational energy term in order to explain the intensity distribution. The potential curves derived have meaningful quantum numbers. The perturbation is caused by the interaction between the $^1\Sigma$ states formed by addition of a hydrogen atom to the $^2P$ and $^2D$ configurations of the silver atom. The dissociation energies of other silver-containing diatomic molecules are discussed. A partial analysis is made of the AgD spectrum. The violent perturbation observed in the hydride is again present. (auth)

**31623** INVESTIGATION OF ANOMALOUS CRYSTAL DISORDERING BY MEANS OF RADIOACTIVE INDICATORS. IX. EFFECTS OF MULTIVALENT IONS ON THE DISTRIBUTION OF A MICROCOMPONENT BETWEEN THE SOLID AND LIQUID PHASES IN THE SYSTEMS $NH_4Cl-CdCl_2-H_2O$ AND $NH_4Br-CuBr_2-H_2O$. E. M. Ioffe. Radiokhimiya, 4: 249-53(1962). (In Russian)

It was found that the capture of cadmium by ammonium chloride crystals is achieved by interabsorption and the formation of defective mixed crystals. In the presence of bromine the copper in $NH_4Br-CuBr_2-H_2O$ is captured by an interadsorption process. It is also shown that both the charge and chemical properties of multivalent ions affect defect formation of mixed crystals. (R.V.J.)

**31624** ON THE NEW URANIUM OXALATE SALTS. A. A. Grinberg, G. I. Petrzhak, and G. S. Lozhkina. Radiokhimiya, 4: 289-95(1962). (In Russian)

Chromium hexacarbamide uranates, $[Cr(N_2H_4CO)_6]_4[U(C_2O_4)_4]_3 \cdot 11\ H_2O$, in which the uranium oxalate is bound with trivalent complex chromium were studied. It is shown that the compound is stable in air and can be produced with saturated $K_4[U(C_2O_4)_4]$ and with saturated $[Cr(N_2H_4CO)_6]Cl_3$. It is also shown that complex compounds of uranium oxalate bonded with complex trivalent Co are not stable due to the redox interactions between components. (R.V.J.)

**31625** SYNTHESIS AND STUDIES OF URANYL SALT COMPLEXES WITH PYRIDINE OXIDE DERIVATIVES. A. V. Nikolaev, V. G. Torzov, V. K. Roman, V. A. Mikhailov, and I. L. Kotlyarevskii. Radiokhimiya, 4: 295-304 (1962). (In Russian)

Eleven complex compounds of uranyl salts with pyridine-n-oxide derivatives; $UO_2(NO_3)_2 \cdot 2PyOx$, $UO_2(NO_3)_2 \cdot 3PyOx$, $UO_2SO_4 \cdot PyOx$, and $UO_2Cl_2 \cdot 2PyOx$; were prepared and their properties were studied. It is postulated that some pyridine-n-oxide derivatives may be used as uranyl nitrate extraction agents. (R.V.J.)

**31626** DETERMINATION OF COMPOSITION AND STABILITY CONSTANTS OF $Am^{3+}$, $Cm^{3+}$, AND $Ce^{3+}$ RHODANIDE COMPLEXES BY ION EXCHANGE. I. A. Lebedev and G. N. Yakovlev. Radiokhimiya, 4: 304-8 (1962). (In Russian)

Sorption of $Am^{3+}$, $Cm^{3+}$, and $Ce^{3+}$ on cation resin at ionic strengths from 0.5 to 5.0 was studied. $AmSCN^{2+}$, $Am(SCN)_3$, $CmSCN^{2+}$, $Cm(SCN)_3$, $CeSCN^{2+}$, and $Ce(SCN)_3$ were prepared and their stability constants calculated. The feasibility of a group separation of trivalent lanthanides and actinides on anionite is discussed. (R.V.J.)

**31627** COMPLEX COMPOUNDS OF LANTHANIDE NITRATES WITH NITRIC ACID. E. E. Kriss and Z. A. Sheka. Radiokhimiya, 4: 312-22(1962). (In Russian)

The formation of a series of trivalent lanthanide complexes in $M(NO_3)_3-HNO_3$ systems was studied by electromigration and ion exchange. It was found that the stabilities and concentrations of cation, neutral, and anion complexes depend on the nitric acid and lanthanide content and the atomic number of the element. It was also revealed that lanthanide cations are predominant in nitric acid solutions of 1 to 1.5 M, while neutral complexes are predominant in ~3 to 4 M solutions. Anion cerium complexes are formed at ~7 M, but the yttrium complexes remain neutral. Formation constants for La and Y complexes are determined. (R.V.J.)

**31628** SORPTION OF LONG-LIFE FISSION PRODUCTS BY SOILS AND CLAYS. III. SELECTIVE SORPTION OF $Sr^{90}$ IN VARIOUS CONDITIONS. Yu. A. Kokotov and R. F. Popova. Radiokhimiya, 4: 328-34(1962). (In Russian)

The selective sorption of $Sr^{90}$ in various soils is based on the variability of $Ca^{2+}$ in the soils (at given volume of exchange). (R.V.J.)

**31629** EFFECTS OF ETHYL ALCOHOL ON STRONTIUM ION SORPTION BY ACTIVE MANGANESE DIOXIDE. Yu. V. Egorov, V. V. Pushkarev, E. V. Tkachenko. Radiokhimiya, 4: 371-3(1962). (In Russian)

Effects of ethyl alcohol additions to water on strontium ion (labeled $Sr^{89}$) affinity to $MnO_2$ were studied. It is shown that with a change of the dielectric constant from 58.0 to 75.5 there is a linear relation, lg a (where a is the Langmuir isotherm parameter), to the reverse magnitude of the water-alcohol dielectric constant. (R.V.J.)

**31630** EXPERIMENTAL DETERMINATION OF CARBON DIOXIDE VOLUME AT 200 TO 750°C AND UP TO 600 kg/cm$^2$ PRESSURE. M. P. Vukalovich, V. V. Altunin, and N. I. Timoshenko (Moscow Inst. of Power Engineering) Teploenergetika, No. 5, 56-62(1962). (In Russian)

Measurements were made of carbon dioxide specific volumes at 200 to 750°C and 11 to 601 kg/cm$^2$ pressures. Experiments made with various piezometers and with various temperature and pressure measuring devices were in good agreement. The tabulated results are correlated with published data. (R.V.J.)

**31631** EXPERIMENTAL DETERMINATION OF HEAVY WATER DENSITY AT HIGH PRESSURES AND TEMPERATURES. S. L. Rivkin and T. S. Akhundov (All-Union Inst. of Thermal Tech., USSR). Teploenergetika, No. 5, 62-5(1962). (In Russian)

The density of heavy water (99.87% $D_2O$) at 50 to 340 k/cm$^2$ pressure and 275 to 425°C was studied and the near-critical parameters were analyzed. The tabulated results

of saturation pressure are in good agreement with published data. (R.V.J.)

**31632** A STUDY OF PRASEODYMIUM OXIDES BY D.T.A. AND DILATOMETER. E. C. Shears and L. I. Ceram (Impregnated Diamond Products Ltd., Gloucester. Eng.). Trans. Brit. Ceram. Soc., 60: 773-82(Nov. 1961).

Differential thermal analysis (D.T.A.) curves obtained on heating and cooling praseodymium oxide powders at 10°C/min in air are given, and shrinkage curves for praseodymium oxide compacts heated in hydrogen, argon, air, and oxygen respectively at one atmosphere are given. The x-ray diffraction patterns resulting from the various firing treatments are briefly described. The shrinkage and D.T.A. curves are in accord and also with the published oxygen–praseodymium equilibrium-phase diagram. (auth)

**31633** VAPOR HYDROLYSIS OF K DOUBLE CHLORIDES AND RARE EARTHS (La, Ce, Pr, Nd). G. I. Novikov and A. K. Baev. Vestnik Leningrad. Univ. Ser. Fiz. i Khim., No. 1, 154-60(1962).

The thermodynamic characteristics of the formation of double salts were determined. The examination was conducted by the static method with a diaphragm zero gage. The enthalpy of formation of 2KCl, $LaCl_3$, $3KCl \cdot 2CeCl_3$, $3KCl \cdot CeCl_3$, $3KCl \cdot 2PrCl_3$, $3KCl \cdot PrCl_3$, $3KCl \cdot 2NdCl_3$, and $3KCl \cdot NdCl_3$ was calculated from experimental data by the equation $\Delta S^{\circ}_{formation} = (\Delta H_{formation})/T + 4.575\ (\log K_T^{I} - \log K_T^{II})$. Pure chlorides of rare earths were produced by chlorinating their oxides with $CCl_4 + Cl_2$ at 600–700°C. They were distilled in a vacuum to remove oxychloride traces. K double salts of rare earths were produced by fusing stoichiometric amounts of rare earth chlorides and K chloride at 700°C in evacuated quartz ampoules. The equilibrium of water vapor hydrolysis was determined in a quartz apparatus with a diaphragm zero gage. The temperature was measured with a platinum–rhodium thermocouple and kept constant with a thermoregulator accurate to 0.5°C. The atmospheric pressure in the apparatus was measured with a gage accurate to 0.1 mm Hg. The more rare earth chlorides are contained in the double salts, the deeper the vapor hydrolysis at the corresponding temperatures. The formation entropy and enthalpy of the rare earth double chlorides were calculated and the results were compared with published data. The relative thermal stability of the compounds is deduced from the data obtained on the formation entropy and enthalpy of rare earth double chlorides. Compounds containing 1 g atom of rare earths per mole, such as $2KCl \cdot LaCl_3$, $3KCl \cdot CeCl_3$, $3KCl \cdot PrCl_3$, and $3KCl \cdot NdCl_3$, are of highest thermal stability. (OTS)

**31634** SUBSTITUTED p-OLIGOPHENYLENES AS SOLUTE FOR LIQUID SCINTILLATORS. Uwe Nay, Hans-Joachim Eichhoff, Guenter Herrmann, and Hermann O. Wirth (Universität Mainz). Z. Elektrochem., 64: 1098-1102(1960). (In German)

The relative pulse height of liquid scintillators with methyl and methoxyl substituted p-quaterphenyls, p-quinquephenyls, and p-sexiphenyls as solutes was measured. Almost all the compounds gave good scintillators. The most favorable properties were shown by the derivatives of p-quaterphenyls, whereas the p-quinquephenyls and p-sexiphenyls, on the other hand, showed no decided advantages. Some of the compounds investigated are at least equivalent in pulse height to known solutes. The excellent solubility and the remarkable stability makes them superior to the known compounds. (tr-auth)

**31635** DIELECTRIC CONSTANTS AND LATTICE VIBRATIONS IN IONIC CRYSTALS. W. Cochran and R. A. Cowley (Cavendish Lab., Cambridge, Eng.). IAEA Preprint No. SM-30/37. 6p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

A number of relations were derived between the static and high-frequency dielectric constants of crystals and the frequencies and polarization properties of optic phonons of small wave-number. The concept of apparent charge is important in this connection. It can be measured experimentally but is not the same as ionic charge. It should be possible to determine apparent charges by a combination of the results of measurement of reflectivity in the infrared, and of neutron inelastic scattering. (auth)

## Radiation Chemistry and Radiochemistry

*Refer also to abstracts 31365, 31368, 31370, 31373, and 31385.*

**31636** (ASD-TDR-62-575) VACUUM TECHNIQUES IN RADIATION CHEMISTRY. Roger E. Rondeau (Aeronautical Systems Div., Wright-Patterson AFB, Ohio). July 1962. 24p.

The high-vacuum apparatus and methods used in the radiation-chemical studies of organic compounds are described. The design and use of high-vacuum systems for the purification, degassing, filling, and sealing of irradiation ampoules are explained. The post-irradiation techniques of removal, separation, measurement, and collection of the volatile products of radiolysis are also described. (auth)

**31637** (BNL-5983) CHEMONUCLEAR PROCESSING. Meyer Steinberg (Brookhaven National Lab., Upton, N. Y.). Feb. 1961. Contract [AT(30-2)-Gen-16]. 4p.

Developments in the use of nuclear energy in the production of chemicals are discussed. The design of a fission fragment chemonuclear reactor is described. (M.C.G.)

**31638** (BNL-5984) THE BROOKHAVEN CHEMONUCLEAR IN-PILE TEST LOOP. W. Tucker, C. Waide, P. Bezler, and M. Steinberg (Brookhaven National Lab., Upton, N. Y.). [Feb. 21, 1962]. Contract [AT(30-2)-Gen-16]. 3p.

A loop was designed for study of chemonuclear systems in a reactor under dynamic conditions. It will be possible to operate the loop under pressures from atmospheric up to 1000 psig, and with temperatures in the gas stream from ambient up to 1000°F. The in-pile section is 40-ft long and composed of 3 concentric stainless steel tubes. A portion of the gas stream in the loop is continuously diverted through an analytical loop. Here samples are taken for analysis in a mass spectrometer, gas chromatograph, and an infrared spectrometer. (M.C.G.)

**31639** (HW-68954(Rev.2)) RADIOLOGICAL DESIGN CRITERIA FOR THE FUEL RECYCLE PILOT PLANT. L. G. Faust and C. M. Unruh (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). July 27, 1962. Contract AT(45-1)-1350. 15p.

Radiological design criteria for the Fuel Recycle Pilot plant are presented. These criteria were developed to assure adequate control of physical conditions related to chronic and acute radiation exposures to personnel, radioactive contamination, and radioactive wastes. (J.R.D.)

**31640** (SGAE-62/3B) BILDUNG RADIOAKTIVER SPALTPRODUKTE IN EINER BESTRAHLTEN URANPROBE IN ABHÄNGIGKEIT VON BESTRAHL- UND ABKÜHLZEIT. (Formation of Radioactive Fission Prod-

ucts in an Irradiated Uranium Sample as a Function of Irradiation and Cooling Time). A. Hoeld (Osterreichische Studiengesellschaft für Atomenergie G.m.b.H., Vienna). [1962]. 15p.

Formulas are derived from which the number of radioactive fission isotopes present during and after nuclear fission can be determined in dependence on the irradiation and cooling time. (tr-auth)

**31641** (TID-16608) PHYSICAL PROPERTIES AND STRUCTURAL CHARACTERISTICS OF POLYMERS RESULTING FROM "POST-EFFECT" POLYMERIZATION. Quarterly Technical Status Report No. 1, March 1, 1962–May 31, 1962. L. W. Elston and W. H. Burrows (Georgia Inst. of Tech., Atlanta. Engineering Experiment Station). June 10, 1962. Contract AT(38-1)-202. 18p.

Activities are reported concerning a survey and review of literature pertinent to the various aspects of this project, formulation of a procedure plan, procurement of equipment, materials and supplies required for the laboratory work, and assembly and construction of the apparatus for polymer fractionation. Methyl methacrylate was chosen as the monomer for initial study. Calibration of equipment will be followed by familiarization experiments utilizing commercially available polymers. (auth)

**31642** (CEA-tr-R-1438) OBTENTION DU $^{32}P$ SANS ENTRAINEUR. (Obtainment of Carrier-Free $P^{32}$). L. S. Kozyreva (France. Commissariat à l'Energie Atomique. Centre d'Etudes Nucléaires, Saclay). Nov. 27, 1961. 18p.

A liquid extraction method is presented for the separation of carrier-free $P^{32}$ from irradiated sulfur. The effects of extraction time and the concentration of the mineral acid were determined. (J.S.R.)

**31643** (FTD-TT-62-817) ELECTROMICROSCOPIC INVESTIGATION OF URANIUM FISSION. N. F. Pravdyuk and V. M. Golyanov (Akademiya Nauk S.S.S.R. Ordena Lenina Institut Atomnoi Energii). Translation of "Electronnomikroskopicheskoye Issledovaniye Deleniya Urana" Moscow, 1962. 30p.

A method of preparing electronmicroscopic specimens of high resolution (~10A), based on the phenomenon of cathode sputtering of metals, was developed. The interaction of fission fragments of $U^{235}$ with the given specimens was studied using an electron microscope of high resolution (down to 7A). It was established that, in specimens with a grain size of less than 40A, the fission fragments form hollow canals with a diameter of from 20A to 200A, which are preserved for a long time. In crystalline specimens with a grain size of more than 100A the canals are not preserved but are "self-healed" as a result of the collective reorganization of atoms. (auth)

**31644** SEPARATION OF CARRIER-FREE $P^{32}$ FROM SULFUR IRRADIATED IN A REACTOR BY ADSORPTION ON ALUMINA. M. Bresesti, A. M. Del Turco, and R. Lanz (Comitato Nazionale per l'Energia Nucleare, Ispra). Ann. chim. (Rome), 51: 351-60(1961). (CNEN-89). (In Italian)

A method for separating carrier free $P^{32}$ from reactor irradiated sulfur is given. The sulfur is dissolved in toluene and the solution is passed through an alumina column which adsorbs the $P^{32}$. 0.5 N NaOH was used as eluant. The resulting solution was made pH2 and was passed through acid Amberlite IR-120 which adsorbs the cations present. The radiochemical purity of the final solution is more than 99%. The separation yield is about 85%. The chemical form of the $P^{32}$ in various stages of the process was studied by means of chromatographic analysis. On the basis of this experiment a glass apparatus screened with plexiglass 12 mm thick was constructed. With this apparatus quantities of carrier free $P^{32}$ of the order of 100 mC can be separated. (tr-auth)

**31645** THE EFFECT OF GAMMA RADIATION ON THE AMINO ACID CONTENT AND THE ENZYMATIC ACTIVITY OF ATP–CREATINE PHOSPHOTRANSFERASE. Felix Friedberg and George A. Hayden (Howard Univ., Washington, D. C.). Arch. Biochem. Biophys., 98: 485-91 (Sept. 1962).

In the intact protein in solution, histidine is most radiosensitive, but in the corresponding amino acid hydrolyzate in solution, methionine is most labile. Phenylalanine and arginine are also faster destroyed if the protein is hydrolyzed before radiation exposure. Since rank in terms of radiation lability varies with individual proteins, stereochemical orientation (amino acid sequence) must be suspected as a determinant. Reconstitution of some amino acids by interconversion during radiation exposure enhances apparent stability of glutamic and aspartic acids, for instance, and their G values with reference to the protein have a destructive and a constructive component. Sulfhydryl (–SH) groups disappear at a faster rate than other amino acid side chains, and decline in enzymic activity is even more rapid than destruction of –SH groups. No decision, however, was reached as to whether destruction of –SH side chains or disruption of protein configuration causes the loss of enzyme activity in the early stages of $\gamma$ irradiation. (auth)

**31646** STUDIES ON THE IRRADIATION OF HIGH POLYMERS AT HIGH TEMPERATURES. II. THE EFFECTS OF OXYGEN AND TEMPERATURE ON THE GEL FORMATION OF POLY(VINYL ALCOHOL) IRRADIATED AT ELEVATED TEMPERATURES. Ichiro Sakurada, Toshio Okada, and Hitoshi Abe. Dôitai to Hôshasen, 4: 134-42(Jan. 1962).

Samples of 0.08 ~ 0.13-mm thick PVA film with a water content of approx 5% were irradiated with a 1000-c $Co^{60}$ source at $3.75 \times 10^4$ r/hr under various conditions. The results showed that the weight loss of PVA was independent of the temperature and atmosphere but was directly proportional to the radiation dosage. A quantitative analysis of the PVA solubility data is described. $G_q$ values of cross-linking were 1.5, 2.7, 4.5, and 30.4 in air, and 1.3, 1.6, 2.2, and 3.8 in vacuo for irradiation at 90, 120, 140, and 170°C, respectively. $G_p$ values for the main fractures were 0.27, 0.32, 0.45, and 0.61 in air, and 0.36, 0.38, 0.47, and 0.76 in vacuo under the same temperature dimensions. The activation energies of cross-linking and main chain fractures were 7.5 and 2.0 kcal/mole in air, and 2.7 and 2.2 kcal/mole in vacuo, respectively, above 100°C. Below this temperature, the activation energies decreased in both cases. (OID)

**31647** STUDIES ON THE IRRADIATION OF HIGH POLYMERS AT HIGH TEMPERATURES. III. THE GEL FORMATION OF UNPLASTICIZED POLY(VINYL CHLORIDE) CONTAINING POLYFUNCTIONAL MONOMERS BY IRRADIATION. Ichiro Sakurada, Toshio Okada, and Noboru Sera. Dôitai to Hôshasen, 4: 143-51(Jan. 1962).

Test results obtained from the irradiation of unplasticized PVC films by $\gamma$ rays from a 1000-c $Co^{60}$ source and by a Van de Graaff accelerator in the temperature range of 30 to 120°C are discussed. Gel formation was not observed when the films were irradiated up to 30 Mr in air at 30°C, but it formed a dosage of 22 Mr in vacuo. The tendency to cross-linking increased with increasing temperature. The G-values of cross-linking in vacuo at 30, 70, 90, and 120°C were 0.12, 0.49, 1.9, and 2.4, respectively. A marked increase in G was observed above the glass transition tem-

perature. The intrinsic viscosity of the sol part in vacuo increased with dosage to a maximum value and then fell off, but it decreased in air between 30 and 70°C. In similar studies on samples containing a small amount of glycol, dimethylacrylate or triallyl cyanurate considerable discoloration was observed only at high temperatures. Very little discoloration was observed in the case of radiation-induced cross-linking of PVC containing a polyfunctional monomer. (OID)

**31648** γ-RAY-INDUCED POLYMERIZATION OF VINYL BENZOATE. Hiroshi Sobue. Dôitai to Hôshasen, 4: 152-6(Jan. 1962).

Vinyl benzoate samples in the boiling point range of 74 ~ 76°C/3 mm Hg were irradiated with a 1000-c source at dosage rate of $8.1 \times 10^4$ r/hr in the temperature range of 40 ~ −20°C in vacuo. The results of induced bulk polymerization were as follows: no induction period was observed; the percentage of conversion up to about 30% was directly proportional to the irradiation time from $3.2 \times 10^3 \sim 5.2 \times 10^3$ r/hr at 15°C; the polymerization rate was proportional to a power of 0.87 of the dosage rate, and the activation energy of polymerization was 2.5 kcal/mole; and the polymer obtained had a relatively low degree of polymerization and was not crystalline. (OID)

**31649** RADIATION POLYMERIZATION OF TRIALLYLCYANURATE IN THE SOLID PHASE. Masaharu Kondo, Akira Matsumoto, and Seiichi Uchida. Dôitai to Hôshasen, 4: 157-61(Jan. 1962).

Purified TAC samples enclosed in glass tubes were irradiated with $Co^{60}$ γ rays at 17, 0, and −70°C. The dosage rate was measured by a Fricke dosimeter with a G-value of 15.6. No dependence of temperature on the conversion yield was observed which indicated that polymerization might proceed predominantly by an ionic mechanism. Spectroscopic studies showed that the remainder of the triazine ring and the disappearance of the unsaturated structure indicated that the reaction occurred by the additional polymerization of allyl radicals. Finally, x-ray diffraction diagrams of the polymer suggested that the polymer produced was amorphous. (OID)

**31650** VAPOR-PHASE RADIOLYSIS OF PROPANE-$d_8$ IN THE PRESENCE OF OTHER HYDROCARBONS. Sharon G. Lias and P. Ausloos (National Bureau of Standards, Washington, D. C.). J. Chem. Phys., 37: 877-83(Aug. 15, 1962).

The radiolysis of propane-$d_8$ was investigated in the presence of saturated and unsaturated hydrocarbons. Radical scavengers were added in all experiments in order to prevent the production of hydrogen, methane, ethane, and ethylene by neutral thermal radical reactions. The formation of ethane could be ascribed mainly to the occurrence of the hydride-transfer reactions $C_2D_5^+ + C_3D_8 \xrightarrow{k_1} C_2D_6 + C_3D_7^+$ and $C_3D_7^+ + RH \xrightarrow{k_2} C_3D_7H + R^+$. When RH = saturated hydrocarbon, the values of $k_2/k_1$ increase with increase in the molecular weight of RH. The observation that olefins and aromatic compounds lower the yield of ethane, but do not affect the rates of formation of molecular methane and ethylene, led to the conclusion that ethyl ions may add to the unsaturated hydrocarbons. Evidence has been obtained for a molecular elimination of hydrogen, methane, ethane, and ethylene from several of the hydrocarbons. (auth)

**31651** THE USE OF HOT ATOM REACTIONS FOR STUDYING INTERMOLECULAR ENERGY TRANSFER IN THE RADIOLYSIS OF ORGANIC COMPOUNDS. V. V. Pozdeev, V. G. Dzantiev, and An. N. Nesmeyanov. Kinetika i Kataliz, 3: 613-14(July-Aug. 1962). (In Russian)

It was previously reported that there is a deviation from direct additivity in the yield of the radiolysis of aliphatic and aromatic hydrocarbons. This problem was investigated by a method involving the introduction of a hot recoil atom into the molecule, resulting in the formation of a labeled and excited molecule which was used for following the energy transfer to the medium. The experiments were carried out with the cyclohexene–tolan system; the first compound is radiation-sensitive while tolan is a stable aromatic compound. A definite proportionality could be established between the yield of the labeled cyclohexene and the molar content of the mixture in this compound; the relationship was not disturbed by further increase of the tolan content. (TTT)

**31652** THE CHEMICAL EFFECTS OF HIGH ENERGY RADIATION; PROSPECTS OF ITS APPLICATION IN THE INDUSTRY. Gyula Hardy (Industrial Plastics Research Inst., Hungarian Academy of Sciences). Magyar Kém. Lapja, No. 2, 52-61(1962).

A short review of the application of radiochemical techniques in the chemical industry is presented. A brief description is given of radiations and of the main types of radiation sources. Radiochemical techniques finding extensive application in the plastics industry are described and discussed under: polymerization in the solid phase as a technique for preparing stereospecific polymers; transformation of polymers, such as radiochemical chlorination, sulfo-chlorination and sulfoxidation; radiochemical grafting; cross-linking of polymers; and radiochemical vulcanization. The introduction of radiochemical techniques into the petroleum processing industry is thought to promise considerable savings, especially when processing large volumes of materials. The composition of irradiated products is identical with those of the thermal cracking while the yield is much larger. Further potential application in the petroleum industry is the desulfurization of petroleum products. Radiochemical techniques in the synthetic organic and inorganic chemical industries are briefly reviewed. The lines of application indicated are preparation of nitric acid, hydrazine, sulfuric acid, hexachlorohexane, and phenol plus telomerization reactions. Finally, technical and economic problems of industrial application are listed: inadequate utilization of the energy of radiation sources; production of homogeneous fields of radiation in large volumes; finding sensitizers to reduce the duration of irradiation required by some reactions; finding the optimum conditions for the radiochemical reactions requiring large amounts of energy; and removal of the products of the reactions from the field of radiation before changes start due to a further amount of undesired radiation. (OTS)

**31653** ENERGY TRANSFER IN THE RADIOLYSIS OF HYDROCARBONS. A. M. Brodskii, Yu. A. Kolbanovskii, and L. S. Polak. Neftekhimiya, 2: 54-67(Jan.-Feb. 1962).

The mechanism of energy transfer during the radiolysis of organic liquids was confirmed. Evaluation of the lower limit of the linear speed of energy transfer indicated the probability of electromagnetic energy transfer (from excited molecules to inhibitor molecules) in the inhibition of radiolysis. The theory allows the prediction of experimental facts, such as variations in the effect of inhibiting additives with their concentration and the relationship between inhibiting effect and the excitation spectrum of molecules participating in the inhibition process. (OTS)

**31654** RADICAL FORMATION DURING LOW-TEMPERATURE SOLID-PHASE γ-RADIOLYSIS. O. L. Lependina, and L. S. Polak. Neftekhimiya, 2: 68-70(Jan.-Feb. 1962).

EPR spectrum analysis of the probability of rupture of various C—H bonds in the radiolysis of solid hydrocarbons at low temperatures showed that the formation during γ radiolysis of radicals having a tertiary carbon atom in the molecule at −196°C occurs mainly by C—H bond rupture at the tertiary carbon atom. In n-dodecane, however, rupture of the C—H bond occurs at both the primary and the secondary carbon atom. (OTS)

**31655** RADICAL SPECIES DETECTED IN γ-IRRADIATED $K^{14}NO_3$ CRYSTALS BY ELECTRON PARAMAGNETIC RESONANCE. J. Cunningham, J. A. McMillan, B. Smaller, and E. Yasaitis (Argonne National Lab., Ill.). Phys. and Chem. Solids, 23: 167-9(Jan.-Feb. 1962). (In English)

Single crystals of $K^{14}NO_3$ and $K^{15}NO_3$, grown from aqueous solution of purified salt, were gamma irradiated at 4.2 or 77°K. Five separate EPR signals were clearly distinguished and individually studied in empirically determined optimum conditions in both crystals. Comparable signals were observed in $K^{15}NO_3$, which showed the same symmetry properties but appeared as doublets with total hyperfine splitting (HFS) reduced, relative to the triplets in $K^{14}NO_3$, in the ratio of the nuclear magnetic moments of $N^{15}$ and $N^{14}$. The results are explained by attributing the EPR signals, termed triplets I, II, III, and IV, to radicals containing nitrogen. The characteristics of each triplet are discussed. (P.C.H.)

**31656** RADIATION-INITIATED CHLOROSULFONYLATION OF POLYISOBUTYLENE. R. V. Dzhagatspanyan, V. I. Zetkin, and V. S. Fedchenko. Plasticheskie Massy, No. 5, 6-9(1962).

Polyisobutylene, with a molecular weight of 100000, was chlorosulfonylated in a $CCl_4$ solution with a mixture of gaseous chlorine and sulfur dioxide under the effect of $Co^{60}$ γ radiation at a dose rate of 90 r/sec. The process was found to begin immediately upon irradiation and to proceed rapidly, limited only by the rate of heat removal, the feed rate, and the degree of mixing of the gaseous and liquid phases. The $SiO:Cl_2$ molar ratio varied from 2:1 to 0.5:1; increasing the ratio above 1.5:1, however, resulted in only a negligible increase in the number of chlorosulfonyl groups per polymer carbon atom, such groups in polyisobutylene being limited to one for every four molecules of the initial monomer. The kinetics of the reaction was not affected by increase in temperature, duration of the process, or by changes, within certain limits, in the concentration of the starting polyisobutylene solution. The chlorosulfonylated polyisobutylene products were white and rubberlike or solid, depending on chlorine and sulfur content. Those with 1 to 4% sulfur and 8 to 40% chlorine exhibited much higher adhesion than the starting polyisobutylene and higher resistance to water, alkalies, and acids. It is noted that chlorosulfonylated polyisobutylene is a low-cost product. Attempts to chlorosulfonylate polyisobutylene with sulfuryl chloride failed. (OTS)

**31657** THE EFFECTS OF α DECAY ON THE CHEMICAL DECOMPOSITION OF AMERICIUM OXALATE. I. A. Lebedev, S. V. Pirozhkov, V. M. Razbitnoi, and G. N. Yakovlev. Radiokhimiya, 4: 308-12(1962). (In Russian)

After 50 to 60 days the precipitate from radioactive $Am_2(C_2O_4)_3$ is $Am_2(CO_3)_3 \cdot 5H_2O$. It is shown that the decomposition is a first reaction with rate constant of 0.22 to 0.04 days. The gas separated during the reaction contains a mixture of $CO_2$ and CO with a prevalence of CO. (R.V.J.)

**31658** RADIOMETRIC METHOD OF DETERMINING ISOTOPIC CONTENT OF Ce SEPARATED FROM HEAVY NUCLEUS FISSION PRODUCTS. S. V. Belov, R. V. Zhelezkov, N. T. Polyakov, and N. V. Sidorov. Radiokhimiya, 4: 334-40(1962). (In Russian)

A radiometric method capable of determining the activity of $Ce^{141}$, $Ce^{143}$, and $Ce^{144}$ — $Pr^{144}$ by a single measurement with a β-γ spectrometer is suggested. The $Pr^{143}$ in the mixture is determined by accumulation of $Ce^{143}$ or by subtracting from the total activity (of $Ce^{141}$, $Ce^{143}$, $Ce^{144}$ — $Pr^{144}$) measured with a 4-π counter. The order of error is ±10%. (R.V.J.)

**31659** SEPARATION OF Te FROM A CsCl TARGET BOMBARDED BY 660 Mev PROTONS. V. N. Rybakov, Ch'uan-P'eng, and Nam Puk Ming. Radiokhimiya, 4: 340-5(1962). (In Russian)

Separation of small quantities of selenium and tellurium was achieved with a strong ASD-2 anionite. The separation of carrier-free Te from a CsCl target was accomplished and a radiochemically pure fraction was obtained. (R.V.J.)

**31660** CHEMICAL TRANSFORMATION IN β DECAY OF $Sb^{125}$ WITH PHENYL AND TOLYL DERIVATIVES. V. D. Nefedov, I. S. Kirin, and V. M. Zaitsev. Radiokhimiya, 4: 351-5(1962). (In Russian)

Chemical transformations in $Sb^{125}$ β decay were studied in phenyl and tolyl derivatives; $Sb^{125}R_3$ and $Sb^{125}R_3Cl_2$. The chemical changes are used for developing new methods for synthesizing phenyl and tolyl derivatives containing tellurium: $Te(C_6H_5)_2$, $Te(C_6H_5)_2Cl_2$, $Te(C_6H_5)_3Cl$, $Te(n-CH_3C_6H_4)_2$, $Te(n-CH_3C_6H_4)_2Cl_2$, and $Te(n-CH_3C_6H_4)_3Cl$. A qualitative analysis is given of the molecular ion fragmentation theory in β decay processes. (R.V.J.)

**31661** CHANGES IN EMANATION AND SEPARATION OF THE SURFACE GAS LABEL IN HYDROXIDE DEHYDRATION. Ch. Ekh, G. M. Zhabrova, S. Z. Roginskii, and M. D. Shibanova. Radiokhimiya, 4: 355-64(1962). (In Russian)

Both examined radiochemical methods, emanation method and the method of surface labeling with inert radioactive gases, proved quite sensitive to hydroxide dehydration processes in systems that form volume solid solutions with thorium dioxide ($Th^{228}O_2-ThO_2$ and $ZrO_2-ThO_2$) and with systems that do not form such solutions ($MgO-ThO_2$, $Al_2O_3-ThO_2$, $ZnO-ThO_2$). A coincidence of emanation and radioactive gas emission temperature with the temperature of initial endothermal dehydration was found. The maximum dehydration endothermal effect was at a higher temperature than the maximum of radioactivity. A more widespread use of the described two radioactive method is suggested. (R.V.J.)

**31662** PREPARATION OF LONG-LIFE $Bi^{210}$. N. B. Abel'skaya, E. G. Gracheva, Z. V. Ershova, V. S. Zverev, V. V. Maslovskaya, and L. Ya. Rudaya. Radiokhimiya, 4: 377-8(1962). (In Russian)

Irradiated metallic Bi was radiochemically separated from Po and other admixtures. The content of Po after 3 months of Bi exposure was $3 \times 10^{-2}$ C/g and the total β activity was $\sim 5 \times 10^{-7}$ C/g. Further purifications eliminated the β-active admixture of Po. The α activity of the Bi solution and of the accumulated $Bi^{210}$ was $1 \times 10^{-8}$ C/g. The specific α activity of the prepared and enriched $Bi^{210}$ specimen was increased to $7 \times 10^{-6}$ C/g. (R.V.J.)

**31663** RADIATION-INDUCED CHAIN OXIDATION IN AQUEOUS Sb(III)—Fe(II) SOLUTION. [PART] I. Niro Matsuura, Yoshimi Kurimura, and Masao Takizawa. Rika Gaku Kenkyūsho Hōkoku, 38: 328(1962).

Radioinduced oxidation of antimony(III)—iron(II) in 0.8 N sulfuric hydrochloric acids was investigated, especially the oxygen effect of the reaction on the yield. The samples

were irradiated at dose rates of $2.29 \times 10^4$ and $6.8 \times 10^4$ r/h for aerated and deaerated systems, respectively, at about 20°C. Only in aerated $H_2SO_4$ medium, was the oxidation found to proceed by a chain reaction, for example, in case of initial concentrations of $4 \times 10^{-4}$ M Sb(III) and $2 \times 10^{-4}$ M Fe(II), two values of G, G[−Sb(III)] of 43 and G[Fe(III)] of 104, were obtained; and under a given initial concentration of Sb(III) of $4 \times 10^{-4}$ M, it was found that $G[-Sb(III)] = 15 \times 10^4 [Fe(II)] + 14$ and $G[Fe(III)] = 39 \times 10^4 [Fe(II)] + 27$, where $[Fe(II)] \leq 2 \times 10^{-4}$ M, and $G[-Sb(III)] = 2.0 [Fe(II)]^{-0.58}$ and $G[Fe(III)] = 1.0 [Fe(II)]^{-0.58}$, where $[Fe(II)] > 2 \times 10^{-4}$ M. G[−Sb(III)] and G[Fe(III)] values in the system of aerated HCl were 2.0 and 6.0, and those in $N_2$-saturated $H_2SO_4$, 0.24 and 0.5, respectively. It is believed that certain behavior of cooperation of Sb(II) and Fe(II) species in dilute $H_2SO_4$ may be largely responsible for the chain oxidation observed. (Sci. Papers Inst. Phys. Chem. Research, Tokyo, 56: June 1962)

**31664** RADIATION EFFECTS ON THE REACTIVITY OF SOLID SURFACES. William H. Cropper (Columbia Univ., New York). Science, 137: 955-61(Sept. 21, 1962).

The possible effects of radiation on the chemical reactivity of solids are described briefly. Three topics are reviewed in detail as examples of the problems involved in such effects: (1) radioinduced adsorption and desorption of $O_2$ on zinc oxide, (2) radiation effects on silica gel's catalytic activity for $H_2-D_2$ isotope exchange reaction and adsorption capacity for $H_2$ and $O_2$, and (3) effects of $S^{35}$ and external radiation on S and O isotope exchange between solid sulfate and $SO_2$ or $O_2$ gas. A bibliography of 53 references is given. (D.L.C.)

**31665** SOME PROBLEMS OF THE RADIOLYSIS OF WATER UNDER THE ACTION OF STRONGLY IONIZING RADIATION. Jerzy Kroh (Łódz Polytechnic Inst., Poland). Wiadomości Chem., No. 3, 135-43(1962).

The accepted mechanism of the radiolysis is given and discussed. Methods of determining the radical and molecular yields (per 100 ev of energy absorbed) are described. Primary and secondary ions formed in the path of an ionizing particle are defined as ionic columns and models of such columns are contrasted. Special attention is focussed on the action of densely ionizing $\alpha$ particles from $Po^{210}$. It was found that the effective path-length of $\alpha$ particles was the controlling factor during the radiolysis of water. Yields of $H^\cdot$, $OH^\cdot$, and $H_2O_2$ evaluated in further studies, using $\beta$ particles from $T^3$, were between those obtained from the radiolysis with $\alpha$ particles from $Po^{210}$ and with $\gamma$ rays from $Co^{60}$. Comparison of the radiolyses of $H_2O$ and $D_2O$ with $\alpha$ and $\beta$ particles, showed the concept of the ionic column to be the more probable one. Radius of the atomic column of D atoms in $D_2O$ is thought to be greater than that of H atoms in $H_2O$. (OTS)

**31666** SEPARATION AND DETERMINATION OF SHORT-LIVED ISOTOPES. F. Strassmann (Johannes-Gutenberg-Universität, Mainz). Z. Elektrochemie, 64: 1011-14(1960). (In German)

Yield determinations in uranium fission are often ruined because of the time requirements of the usual methods when a short-lived primary product is involved. Because of the needs for short times and clean separation and isolation, methods from classical radiochemistry were tested for their applicability to fission products. Direct and indirect determinations using radioactive recoils and electrolytic reduction and oxidation were carried out with the utilization of model substances since a radiation source of suitable output was not available. (tr-auth)

**31667** STUDY OF ORGANIC REACTIVITY USING RADIOACTIVE ISOTOPES. D. Gál, F. Dutka, L. Guczi, I. Kende, and M. Koch. Z. Physik. Chem. (Frankfurt), 17: 43-55(1958). (In German)

The kinetics of the isotope exchange reactions of alkyl and aralkyl iodides and the effect on anilines on these processes were studied. The kinetics of the desorption of alkyl iodides on activated carbon and red phosphorus were followed experimentally. From the desorption data and from the application of differential isotopic methods, it was shown that, simultaneously with the adsorption, chemical reactions occur in the case of red phosphorus, whereas in the case of activated carbon a reversible adsorption is present. These facts were supported by the research data obtained in the isotope exchange reactions between adsorbed organic iodides and the potassium iodide present in the liquid phase. (tr-auth)

**31668** RECOMBINATION OF RADICALS FROM VARIOUS TRACKS OF RADIOLYSIS AND HOMOGENEOUS KINETICS. II. APPLICATIONS OF ALLEN MODEL WITH HOMOGENEOUS KINETICS AND CONSTANT INITIAL YIELD. V. M. Byakov and B. V. Eshler. Zhur. Fiz. Khim., 36: 1597-1602(July 1962). (In Russian)

Radical recombinations were studied in $FeSO_4$ solution where H atoms compete in two reactions: 1) H + H recombination with constant k and 2) $H + H^+$ capture with constant $k_A$. The Allen model evaluation and homogeneous kinetics with constant initial yield of $H_2$, $H_2O_2$, H, and OH, for a wide range of concentrations and intensities, produced identical results to those obtained with precise considerations for diffusion. (R.V.J.)

**31669** THE EFFECTS OF IONIZING RADIATION ON POLYSACCHARIDES. A. S. Freydin and Yu. M. Malinskii. p.130-59 of "Vsesoyuznoye khimicheskoye obshchestvo imeni D. I. Mendeleyeva. Uspekhi khimii i tekhnologii polimerov, sb.3." Moscow, Goskhimizdat, 1960.

A summary of experimental results of the irradiation of mono- and polysaccharides with high-speed electrons, x and $\gamma$ rays and neutrons is presented. The summary is divided into three parts: the action of radiation on simple saccharides, such as glucose, fructose, lactose, sucrose, and raffinose; the action of radiation on polysaccharides (except cellulose)—agar, insulin, gum arabic, starch, amylose, pectin, amylopectin, dextran, alginic acid, and some mucosaccharides; and the effects of irradiating cellulose and its derivatives—wood and cotton cellulose, nitro-, aceto-, and ethyl cellulose, and cellophane. (OTS)

## Raw Materials and Feed Materials

**31670** ADSORPTION EQUILIBRIUM KINETICS IN LEACHING WITH RADIOACTIVE TRACERS. I. E. Starik and K. F. Lazarev. Radiokhimiya, 4: 322-8(1962). (In Russian)

Investigations of thorium and monazite leaching kinetics show that the necessary times for equilibrium between the mineral and solution and for complete mixing depend on the $H^+$ concentration and on the dissolution rate of Th hydrolysis products. The results indicate for monazite leaching by 0.07 N sulfuric acid and 0.23 and 1.1 N hydrochloric acid the equilibrium is reached at 8, 3, and 1 hour, respectively. (R.V.J.)

## Separation Processes

*Refer also to abstracts 32042, 32051, and 32055.*

**31671** (AAEC/TM-134) COST ESTIMATION FOR NUCLEAR REPROCESSING PLANTS—A COMPARISON OF METHODS. P. G. Alfredson and R. C. Cairns (Australia.

Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). Mar. 1962. 14p.

A comparison of methods of capital cost estimation used for nuclear reprocessing plants shows that, because of the special nature and complexity of such plants, cost estimation methods for conventional chemical plants involving the use of cost factors are not applicable and will give low estimates. Cost factors which are available from other countries where reprocessing plants are installed should be used with caution since these factors apply only for the particular design philosophy used and pertain to industrial conditions which are different in this country. Capital cost estimation methods involving direct take-offs from detailed design drawings are necessary to obtain reliable estimates. The methods of estimating operating costs for nuclear reprocessing and conventional chemical plants are similar. (auth)

**31672** (AERE-R-4107) PROCESSING STUDIES ON CARBIDE–GRAPHITE FUEL ELEMENTS FOR A HIGH TEMPERATURE GAS-COOLED REACTOR. K. R. Hyde and D. J. O'Connor (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Aug. 1962. 40p. (AERE-C/R-2321)

Results of processing studies on fuels proposed for a High Temperature Gas-Cooled (H.T.G.C.) reactor are described. Studies were made on graphite, U, and Th powders cold compacted and fired at 1400°C, and Th incorporated and U impregnated graphite. Processing methods such as oxidation, acid and alkali leaching, high pressure leaching, anodic leaching, and halogenation were investigated. Nitric acid (2 to 4N) leaching at 90 to 100°C is recommended as the primary processing method, whereby U and Th are obtained in solution suitable for conventional solvent extraction. The process of anodic disintegration was established as suitable for "opening-up" graphite fuels. (auth)

**31673** (HW-71054) SIMULATION OF THE ZIRFLEX PROCESS WITH AN ANALOG COMPUTER. P. W. Smith (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Oct. 25, 1961. Contract AT(45-1)-1350. 40p.

The Zirflex process was studied extensively at Hanford in the development of technology for the interim reprocessing of power reactor fuels. The process involves the dissolution of Zircaloy in aqueous ammonium fluoride–ammonium nitrate solution. It is of particular interest at Hanford because of the impending fuel recovery from Zircaloy-clad PRTR and NPR elements. The chemical kinetics of the Zirflex reaction were not fully defined at the end of the original studies. However, a pseudo first order reaction with "free" fluoride (fluoride not complexed with Zr) was deemed to describe the kinetics adequately for engineering calculations. The refined kinetic equation and the analog computer solution on model of the system are discussed. The results of thirty computer simulated dissolutions are also presented, and the data are used to illustrate the effects of the process variables on the Zirflex dissolution time cycle. The data from a selected few of the runs are directly applicable to the reprocessing of PRTR fuel elements in Redox. It was found that the Zirflex reaction kinetics are dependent on "free" fluoride ion to the 2.017 power and on H ion to the 0.457 power according to laboratory data secured after completion of the original research and development studies. The direct integration of the kinetic equation was prevented by the complex interdependence of the chemical variables. However, an analog computer circuit was evolved which was used to solve the defining equations simultaneously. The circuitry is discussed in the report because of its applicability to future studies and its novel aspects. The data from the computer runs verified the results of the earlier laboratory and pilot plant work. However, a much clearer view of the process is presented with the continuous graphs of the variables prepared from the computer data. In addition, data not available from the pilot plant studies but applicable to Redox reprocessing of PRTR fuels are presented. (auth)

**31674** (IDO-14304) PILOT PLANT STUDIES OF CONTINUOUS NITRIC ACID DISSOLUTION OF URANIUM–ALUMINUM ALLOY. D. M. Paige, A. F. Boeglin, J. A. Buckham, L. Chajson, R. B. Lemon, and C. E. Stoops (Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho). May 30, 1954. Contract AT(10-1)-205. 28p.

Pilot plant studies were made of the continuous nitric acid dissolution of 7.5% uranium-92.5% aluminum alloy slugs. Seventy-two runs were completed in a two-inch diameter by fifteen-foot high glass-pipe dissolver. Maximum dissolution rates achieved were about 1.0 kg uranium per day from cast alloy, and 1.5 kg uranium per day from extruded alloy, per square inch of dissolver cross-section. The optimum feed acid concentration was about 5M. The feasibility of continuous upflow dissolution of uranium-aluminum slugs in a flooded dissolver was proven and preliminary data for the design of a plant-scale dissolver were obtained. (auth)

**31675** (ORNL-3280) USE OF FUSED SALT-FLUORIDE VOLATILITY PROCESS WITH IRRADIATED URANIA DECAYED 15-30 DAYS. G. I. Cathers, R. L. Jolley, and H. F. Soard (Oak Ridge National Lab., Tenn.). Sept. 20, 1962. Contract W-7405-eng-26. 29p.

In laboratory tests U recovered from irradiated $UO_2$ fuel decayed 15 to 30 days was highly decontaminated from short-half-life fission products by the fused salt-fluoride volatility process. Radioactive $I_2$ and Te, which form volatile fluorides, were effectively separated from the $UF_6$ product in the NaF absorption step operated at 100°C. Radioactive Nb, Ru, and Zr behaved in accordance with previous work, resulting also in good decontamination of the $UF_6$ product from their respective fluorides. The behavior of $Mo^{99}F_6$ with a half life of 6.7 hr in the NaF absorption step was in agreement with other work on the $MoF_6$-NaF system. The disappearance of radioactive $I_2$, Te, Nb, Ru, and Mo in the fused salt dissolution step indicated that precipitation or volatilization and condensation at the top of the dissolution reactor occurred, with not much of the material being carried out of the vessel with the excess HF. Dissolution rates for the irradiated $UO_2$ clad in Zircaloy-2, used as feed material, were approximately the same as those obtained with unirradiated material. (auth)

**31676** (ORNL-TM-222) CHEMICAL TECHNOLOGY DIVISION, UNIT OPERATIONS SECTION MONTHLY PROGRESS REPORT, MARCH 1962. M. E. Whatley, P. A. Haas, R. W. Horton, A. D. Ryon, J. C. Suddath, and C. D. Watson (Oak Ridge National Lab., Tenn.). Sept. 18, 1962. Contract [W-7405-eng-26]. 74p.

Four geometrical variations of stacked hydroclones in combination with five variations of vortex finder or overflow arrangements were tested in the extraction of uranyl nitrate from 1 M $NaNO_3$ into 18.3% TBP-Amsco, showing flooding throughputs of 1200 to 4800 cc/min (aqueous plus organic) and stage efficiencies of 2% to 76%. Wear testing of the stepped moving blade of the shear by shearing ORNL Mark I fuel 36 tubular assembly filled with porcelain is about 50% completed: the blade was not noticeably changed

after 2000 cuts. Particle size measurements on 1 in. shear cut fractions shows that ~10% of the particles were <9520 μ and ~2.5% are <100 μ. Stage efficiency values for solvent extraction and stripping using uranium as a stand-in for plutonium were determined as part of the amine extraction final cycle plutonium flowsheet studies. A fluorine-charcoal reactor, a possible fluorine disposal device, was operated without incident to produce an off-gas containing less than 100 ppm $F_2$. (auth)

**31677** (ORNL-TM-384) U–Th RECOVERY FROM PYROLYTIC CARBON-COATED CARBIDE FUEL PARTICLES BY ELECTROLYSIS IN NITRIC ACID. A. H. Kibbey and L. M. Ferris (Oak Ridge National Lab., Tenn.). Sept. 26, 1962. Contract [W-7405-eng-26]. 7p.

Electrodissolver experiments were conducted with pyrolytic C-coated $UC_2$–$ThC_2$ fuel particles in both a direct contact anode dissolver and a U-shaped "series" dissolver. Under the conditions investigated ($HNO_3$ concentration, 4-10 M; current density, 1 to 10 amp/cm$^2$; temperature 25 to 80°C), U and Th recoveries were less than 0.2%. The results of these experiments indicated that electrolytic methods are not adaptable to the processing of graphite-base reactor fuels containing carbon-coated particles. (auth)

**31678** LIQUID–LIQUID EXTRACTOR. APPLICATION TO SEPARATION OF STRONTIUM AND BARIUM. Harley A. Wilhelm and Maurice L. Andrews (Iowa State Univ. of Science and Tech., Ames). Ind. Eng. Chem., Process Design Develop., 1: 305-9(Oct. 1962). (IS-363)

A laboratory-size, 20-stage, multiple-contact, "unlimited-feed," countercurrent-flow, liquid-liquid extractor is described. The apparatus consists mainly of glass parts, joined by polyethylene tubing and mounted in a steel cradle that can rotate on its horizontal axis. The reservoirs for feed liquids are an integral part of the assembly. Proper rotation of the assembly causes the flow of liquid to, through, and from the extractor. Use of this extractor is exemplified by a study on the liquid-liquid separation of strontium and barium. Starting with an aqueous feed 0.5M in $SrCl_2$ and 0.5M in $BaCl_2$, a barium product containing less than 100 ppm of strontium was delivered in the aqueous phase, while moderately pure strontium was obtained in the organic product phase. (auth)

**31679** EXTRACTION OF URANYL NITRATES BY UNDILUTED TBP. A. V. Nikolaev, S. D. Durasova, and B. V. Levin (Kurnakov Inst. of General and Inorganic Chemistry, Moscow). Izvest. Sibir. Otdel. Akad. Nauk S.S.S.R., No. 6, 102-5(1962). (In Russian)

Extraction of 99.5% of the U from uranyl nitrate by undiluted TBP was achieved with a 5.5-m packed column using a 4-m column of $Mg(NO_3)_2$ as salting-out agent. Extraction in a column doubles the U concentration. The pulse type column was two or three fold more efficient than the packed column, however, it was impossible to use undiluted TBP in the pulse column. (R.V.J.)

**31680** EXTRACTION OF Ca(II), AND Ba(II) BY ACIDIC ESTERS OF PHOSPHORUS OXY ACIDS. D. F. Peppard, G. W. Mason, S. McCarty, and F. D. Johnson (Argonne National Lab., Ill.). J. Inorg. & Nuclear Chem., 24: 321-32 (Mar. 1962). (In English)

The extraction of Ca(II), Sr(II), and Ba(II) from aqueous mineral acid, in the presence and absence of the corresponding sodium salt, into xylene solutions of $(GO)_2PO(OH)$, G = 2-ethyl hexyl and para (1,1,3,3 tetramethyl butyl) phenyl, and of (GO)G'PO(OH), G = n-octyl and G' = phenyl and chloro methyl, was investigated radiometrically. The distribution ratio, K, was found to be inversely second-power dependent upon the hydrogen ion concentration in the equilibrated aqueous phase. The dependency of K upon the concentration of extractant in the equilibrated xylene phase was found to be 2.5-power for Ca and Sr and 3.0-power for Ba in systems involving bis [para (1,1,3,3 tetramethyl butyl) phenyl] phosphoric acid or n-octyl hydrogen chloromethyl phosphonate; 3.0-power for Ca, Sr, and Ba in systems involving n-octyl hydrogen phenyl phosphonate; and 3.0-power for Ca (Sr and Ba not proved) in systems involving bis(2-ethyl hexyl) phosphoric acid. The effect of structural differences in the extractants is discussed, and the extraction of alkaline earths (II) is compared with that of Pm(III) and Cm(III). (auth)

**31681** THE EFFECTS OF SOLVENT PROPERTIES ON THE EXTRACTION OF INTRACOMPLEX COMPOUNDS. Yu. A. Zolotov and I. P. Alimarin. Radiokhimiya, 4: 272-9 (1962). (In Russian)

Extraction of Np(V), Ce(III), and Co(II) thenoyltrifluoroacetonates, Np(V) hydroxyquinolinate, Co(II) acetylacetonate, and other complex compounds was analyzed considering the properties of organic solvents. The Np(V) and Co(II) are easily extracted by thenoyltrifluoroacetone in isobutyl alcohol. Cobalt acetylacetonate is freely extracted by isobutyl alcohol. As a rule the active oxysolvents, especially alcohols, have better solvent properties than simple ethers, hydrocarbons, and their halide substitutes. Separation of coordinate saturated and coordinate nonsaturated complexes was achieved. (R.V.J.)

**31682** EXTRACTION OF MICROQUANTITIES OF Ce FROM NITRATE SOLUTIONS BY METHYLPHOSPHONIC ACID DI- AND MONOISOAMYL ESTERS. E. V. Ukraintsev and N. F. Kashcheev. Radiokhimiya, 4: 279-89(1962). (In Russian)

Solvent extraction of Ce(III) by DAMPA (diisoamyl ester of methylphosphonic acid) was analyzed. Complex formation constants were determined for benzene and xylene diluents (12 ± 3) and for kerosene (~62 ± 1.5) at constant ionic strength (~2). The thermodynamic constant for benzene diluent is ~30 to 40. The extraction of Ce by methylphosphonic acid monoisoamyl ester as $Ce(NO_3)$ $(MAMPA^-)_2$. $(MAMPA)_2$ was analyzed and a reaction constant of 0.126 ± 0.002 was found. Effects on nitric acid, thorium nitrate, and $NO_3^-$ in aqueous solution on Ce distribution were determined. It is also shown that the presence of MAMPA and DAMPA increases Ce extraction due to synergic effects. (R.V.J.)

**31683** THE ANALYTICAL APPLICATION OF FLUORIC ION. [PART] III. SOLVENT EXTRACTION OF THORIUM. Jisuke Seki. Rika Gaku Kenkyûsho Hôkoku, 38: 334(1962).

The conditions of solvent extraction of thorium and the effects of TBP diluents were studied. The separation of thorium from cerium was also examined. (Sci. Papers Inst. Phys. Chem. Research, Tokyo, 56: June 1962)

**31684** THE ANALYTICAL APPLICATION OF FLUORIC ION. [PART] IV. SOLVENT EXTRACTION OF THORIUM IN FLUORIDE. Jisuke Seki. Rika Gaku Kenkyûsho Hôkoku, 38: 342(1962).

Thorium was extracted from a mixture of thorium fluoride in 50% aluminum nitrate and nitric acid with TBP–nHexane. The ions extracted with 20% TBP-nHexane were mainly thorium and a small amount of cerium. Few of the rare earth elements except cerium were extracted. The separation of thorium from thorium ore was satisfactorily made with 50% TBP–nHexane. (Sci. Papers Inst. Phys. Chem. Research, Tokyo, 56: June 1962)

**31685** THE ANALYTICAL APPLICATION OF FLUORIC ION. [PART] V. METHOD OF SEPARATING THORIUM FROM RARE EARTH ELEMENTS. Jisuke Seki. Rika Gaku Kenkyûsho Hôkoku, 38: 348(1962).

Thorium was precipitated as oxinate after masking the rare earth elements with EDTA. The precipitate obtained method was filtered off, washed, and dissolved in hydrochloric acid, and the quantity of thorium was determined by direct titration with fluoric ion, keeping the solution at pH 2.4. Good results were obtained by applying the method to the analysis of monazite. (Sci. Papers Inst. Phys. Chem. Research, Tokyo, 56: June 1962)

**31686** INVESTIGATIONS ON FLOTATING BERYLLIUM. I. T. Leviush and M. A. Eygeles. Trudy Vsesoyuz. Nauch.-Issledovatel'. Inst. Mineral'. Syr'ya, No. 6, 106-122([1961]).

The fixation of individual reagents and compounds on minerals was determined by radiometric and chemical methods; the induction time when mineral particles adhered to an air bubble and carried out flotation of some pure minerals, their synthetic mixtures, and particular ores were measured. Fluorspar (albite) and crushed pegmatite were added as a gangue to the composition of the synthetic mixture. The beryllium content in the mixtures was 1%. The beryllium size was 0.15 – 0.1 mm, albite or pegmatite size was 0.074 – 0.02 mm. The dependence of $Ca^{45}$ and $Fe^{59}$ sorption on beryllium and fluorspar upon their concentration in the solution and pH of the medium was revealed. It is noted that in weakly-acid, neutral, and alkaline media, a parallel proceeding Fe-hydroxide precipitation process is superposed on the sorption process. The fixing of fatty-acid collectors on beryllium and fluorspar under various conditions was measured. Higher temperatures reduce the fixation of collectors on beryllium. Beryllium activation and fluorspar activation with multivalent metal salts, contained in natural water and waste products of mills, increase the flotation extraction of minerals when using oleic acid as a collector. It is shown that the use of Na-cationized water for the flotation of synthetic mixtures of beryllium-albite and beryllium ores, makes it possible to considerably increase selectivity of beryllium flotation. Heating the pulp to 85-90°C prior to adding the oleic acid and the use of Na-cationized water substantially raise the selectivity of beryllium flotation from synthetic mixtures and ores. (Referativnyy Zhurnal, Metallurgiya, No. 2, 1962)

**31687** COMPARATIVE STUDIES OF SOLVENT EXTRACTION OF PROTACTINIUM, TANTALUM, NIOBIUM, AND ZIRCONIUM FROM STRONG HYDROCHLORIC ACID. Hans-Ludwig Scherff and Guenter Herrmann (Universität, Mainz). Z. Elektrochemie, 64: 1022-33(1960). (In German)

The extraction of Pa, Ta, Nb, and Zr from strong HCl solutions was investigated with the following extraction media: undiluted tri-n-butylphosphate, 0.01 M tri-n-octylphosphine oxide in benzene, and undiluted di-isobutylcarbinol. In addition to pure HCl, mixtures with strong complexing agents–hydrofluoric acid, oxalic acid, and tartaric acid–as well as pure perchloric acid as the aqueous phase were used. From the data obtained a simple method for obtaining pure Pa from concentrates was given: Ta and Nb were extracted from 6N HCl–1-3N HF with diisobutylcarbinol and then the aqueous phase was saturated with $AlCl_3$. The Pa was then extracted with the same extractant. Zr remains in the aqueous phase. The chemical behavior of the four elements in these aqueous phases was qualitatively compared. Pa showed a greater similarity to Zr than to its homologs Ta and Nb. (tr-auth)

**31688** APPARATUS FOR THE SEPARATION OF FLOWABLE MIXTURES, ESPECIALLY OF AN ISOTOPE AND GAS MIXTURE WITH THERMODIFFUSION. Fritz Schultz-Grunow. German Patent DBP 1,109,650. Jan. 4, 1962.

Equipment for separation of gases and isotopes by thermal diffusion is described. The apparatus consists of stationary housing and rotating disk with narrow absorbing slits connecting housing and disk. The disk is cooled from inside and the housing is heated, or vice versa. Outlet pipes for enriched components are arranged on the inner and outer circumferences of the housing. (M.C.G.)

**31689** PROCESS FOR SEPARATING NIOBIUM AND TANTALUM. Walter Scheller (to CIBA Aktiengesellschaft). Swiss Patent 348,398. Oct. 14, 1960.

A niobium and tantalum halogenide- or oxyhalogenide-containing mixture is dissolved in a waterfree, alcohol containing solvent, and treated with 8-oxychinolin under the at least partial removal of the halogen–hydrogen acid which forms during the solution of the halogenide. The products formed, which contain difficult-to-dissolve to nonsoluble nioboxychinolate, are separated from the solution, and tantaloxychinolate is obtained from the latter. (OTS)

# ENGINEERING AND EQUIPMENT

## General and Miscellaneous

**31690** (ARF-3187-8) ELECTROSTATIC CLASSIFICATION OF SUBMICRON AIRBORNE PARTICLES. Progress Report, June 1 to August 1, 1962. G. Langer (Illinois Inst. of Tech., Chicago. Armour Research Foundation). Contract AT(11-1)-578. 26p.

Progress is reported in a study of electrostatic classification of submicron airborne particles, with emphasis on particles smaller than 0.1 micron. Modifications in design of a gas ionizer and an electrostatic classifier are discussed and illustrated by schematic sketches. Initial tests using the classifier were made with atmospheric dust. Results are discussed and proposals are included for equipment modification. A classifier was designed and tested that employs a nonuniform electric field for particle size classification. Analysis was begun of the interaction of the fluid flow field and the electrostatic field. The influence of Brownian movement, optimum aerosol inlet position, and trajectory of charged particles on results are discussed. (C.H.)

**31691** (CRE-1104) A COMPARISON OF THE OPERATING CHARACTERISTICS OF FLAT-FACE AND HYDRODYNAMICALLY LUBRICATED ROTATING MECHANICAL SHAFT SEALS IN HIGH PRESSURE WATER. R. D. Watson and K. W. Roche (Atomic Energy of Canada Ltd., Chalk River, Ont.). Aug. 1962. 37p. (AECL-1588)

Flat-face seals can be hydrostatically balanced to give low leakage rates and moderately low contact loads at the faces but the seal balance is extremely sensitive to changes in operation conditions. An increase in temperature or a decrease in pressure is followed by a large decrease in leakage, making it difficult to maintain a proper balance over a wide range of conditions. Excessive unbalance causes scuffing of the faces which leads to a greater unbalance and ultimately to failure. Taper-face seals however, develop a hydrodynamic film between the faces that adjusts to changes in pressure and temperature and can be designed to operate over a wider range of conditions than the flat-face seals. They can be balanced so that the leak rate is almost independent of the system pressure and only slightly affected by a change in water temperature. On the other hand, the leak rate increases rapidly with speed and the balance must be adjusted to compensate for this. Starting is often difficult because the hydrodynamic film is not available to provide the proper balance, but this can be overcome. When the seals are properly balanced the friction torque of both flat-face and taper-face seals is less than 2 lb in. at 1900 rpm in water at 800 $lb/in^2$. The results of numerous tests on both flat-face and taper-face seals operating under different conditions are presented in graphical form. (auth)

**31692** (NP-12020) DYNAMIC SHAFT SEALS IN SPACE. First Quarterly Report for Period Ending July 15, 1962. (General Electric Co. Spacecraft Dept., Cincinnati). Contract AF 33(657)-8459. 80p.

The development of dynamic shaft seals for space applications is considered. The seals considered must operate on high speed rotating shafts under conditions of high temperature liquid metals and vapors, and near-vacuum environments of space. The 20,000 rpm water seal test rig was designed and analytical investigation of screw seals started. Design layouts were completed on various configurations of the stationary housing-rotating disk and the squeeze seal. The design of the high speed test rig to be used for liquid metal (potassium) testing and its auxiliaries required for liquid operation is described. Water pretesting of rotating fluid ring seals is evaluated. (N.W.R.)

**31693** (PNE-103F) THE SEQUENCED GAS SAMPLING EXPERIMENT. Final Report. J. W. Landry (Oak Ridge National Lab., Tenn.). Aug. 1962. Contract [W-7405-eng-26]. Project GNOME. 35p.

Six samples were drawn, in a predetermined time sequence, from the prompt sampler in the radioisotopes recovery experiment of Project Gnome. No material from the detonation was detected in the samples. Samples and specimens from other Project Gnome experiments relating to the chemical applications of nuclear explosions are mentioned. (auth)

**31694** (PNE-150F) SEISMIC WAVES FROM AN UNDERGROUND EXPLOSION IN A SALT BED. D. S. Carder, W. K. Cloud, W. V. Mickey, J. N. Jordan, and D. W. Gordon (Coast and Geodetic Survey, Washington, D. C.). Aug. 1962. Contract AT(29-2)-746. Project GNOME. 60p.

Seismic waves resulting from a low yield nuclear detonation 1200 feet deep in a salt bed near Carlsbad, New Mexico, were measured by strong-motion seismographs operated by the Coast and Geodetic Survey on the surface in the distance range from 0.5 to 8.8 miles and underground in a potash mine 8.7 to 11.2 miles distant. In addition, many temporary and permanent seismographs were operated by the Coast and Geodetic Survey and other organizations on a continent-wide and a world-wide basis. Ground particle accelerations exceeded those from the Logan shot, a like detonation in tuff, by a factor of about 4, and accelerations underground in the salt bed were about half those on the nearby surface. There was no evidence of damaging accelerations in nearby commercial operations or dwellings. Nearby transient ground particle displacements were about the same as those from the Logan shot, except that the frequencies were higher. Attenuation with distance across the plains to the east was relatively low as compared with similar effects in the mountain and plateau area toward the west. Upper mantle velocities likewise were higher toward the east, 8.3 to 8.4 km/sec, as compared with 7.8 to 8.1 km/sec toward the north, west, and northwest. The estimated magnitude of the GNOME shot was from 4.6 to 5.0, depending on the choice of data. (auth)

**31695** (SCTM-249-61(14)) THE EFFECT OF IMPERFECT VACUA UPON THE PURITY OF EVAPORATED MATERIALS. G. L. Krieger (Sandia Corp., Albuquerque, N. Mex.). Sept. 1961. Reprinted Jan. 1962. Contract [AT(29-1)-789]. 8p.

The parameters affecting the gas contamination of vacuum deposited materials are discussed. Equations are derived relating the contamination to measurable conditions associated with the evaporation process, and graphs are given covering the range of commonly encountered conditions. (auth)

**31696** (TID-16828) EBR II FUEL DISMANTLING EQUIPMENT. J. P. Simon and R. B. Wehrle (Argonne National Lab., Ill.). July 1962. Contract [W-31-109-eng-38]. 13p. (UAC-6683)

A remotely operated prototype machine was fabricated for the mechanical dismantling of the fuel subassembly of the Experimental Breeder Reactor II. Chipless cutters facilitate removal of the stainless steel hexagonal jacket. A fuel element removing machine retrieves the elements from their array for inspection and delivery to the fuel decladding operation. Continuous cooling is applied to the fuel element array to remove decay heat. The machine is constructed in units to facilitate its remote repair. Radiation resistant materials were used for pneumatic seals, electrical insulation, and lubrication to minimize the effects of radiation. (auth)

**31697** A 560kv ACCELERATOR FOR THE STUDY OF PHOTOREACTIONS. D. Bollini, A. Cambieri, F. Fossati, and S. Rovera (Università, Pavia). Energia nucleare (Milan), 9: 397-9(July 1962). (In Italian)

A 560 kv electrostatic accelerator for protons, in operation at the Physics Institute of the University of Pavia, is described. Recently this accelerator was supplied with a radiofrequency ion source by which it is possible to obtain, through a reaction on $Li^7$, a beam of $\gamma$ rays of 14.8 and 17.6 Mev having an intensity of $4 \cdot 10^8\ \gamma/(4\ \pi$ sec). (auth)

**31698** SUGAR IMPREGNATION OF GRAPHITE. Norman W. Rogers (United Power Co. Ltd., Erith, Eng.) and E. M. Haines. Ind. Chemist, 38: 397-400(Aug. 1962).

Sugar impregnation is a highly efficacious method for reducing the permeability of graphite by a factor of 50 up to $10^6$. A commercial plant was built for carrying out the impregnation on a large scale, and the new specialized equipment used in the plant is described. (D.L.C.)

**31699** DESIGN AND PLANNING OF EQUIPMENT FOR HIGH PRESSURE LOOP EXPERIMENTS. T. Hayes and D. Walmsley (United Kingdom Atomic Energy Authority, Harwell, Berks, Eng.). Ind. Chemist, 38: 418-23(Aug. 1962).

The design of experimental loops for high-pressure studies, e.g., of reactor irradiation and corrosion, is discussed. Design aspects which are considered in detail are layout, accessibility, siting, choice of instrumentation, sampling, and safety. Experience obtained from high-pressure water loops is described. (D.L.C.)

**31700** FLEXURE OF A CIRCULAR PLATE WITH A RING OF HOLES. H. Kraus (Westinghouse Electric Corp., Pittsburgh). J. Appl. Mechanics, 29: 489-96(Sept. 1962). (WAPD-T-1145)

The problem of the moment distribution resulting from a uniform pressure load acting over the surface of a circular plate containing a ring of equally spaced circular holes with, and without, a central circular hole is solved within the framework of the Poisson-Kirchhoff theory of plates. A general boundary condition is applied at the outer rim of the plate to make the solution valid for a range of conditions from the simply supported case to the clamped case. The edges of the perforations are allowed to be either free or to have a net shear force acting. Numerical results in the form of curves are given for typical cases, and the results of a photoelastic test are also presented. (auth)

**31701** CHARACTERISTICS OF THE FLOW OF AN IONIZED PERFECT GAS THROUGH A MAGNETIC FIELD. E. N. Carabateas (Massachusetts Inst. of Tech., Cambridge) and G. N. Hatsopoulos. J. Appl. Mechanics, 29: 568-74(Sept. 1962).

The problem of the compressible flow of a perfect gas with constant fractional ionization through a magnetic field is considered. The Joulean heat dissipation is assumed to be taken out of the gas so that the flow can be treated as isentropic. The present analysis differs slightly from others previously reported in the literature mainly in that the entire conductivity tensor and the variation of its elements with gas properties are taken into account. It is felt that the somewhat unrealistic condition of isentropic flow is much less restrictive than the assumption of a scalar constant conductivity. Under these conditions, a relatively simple integration of the flow equations is possible. The assumption of isentropic flow implies that the difference in stagnation enthalpies at the entrance and exit of the magnetic field region is equal to the electrical output plus the Joulean heat. Therefore the ratio of the output power to the difference in stagnation enthalpies gives a measure of the Joulean heat dissipation and hence of the efficiency of the device. (auth)

**31702** A NEGATIVE ION SOURCE USING A MERCURY POOL CATHODE. Ralph H. V. M. Dawton (National Inst. for Research in Nuclear Science, Harwell, Berks, Eng.). Nature, 195: 1190(Sept. 22, 1962).

A negative ion source in which the filament is replaced by a mercury cathode gives large currents up to 700 amp-pulse and long lives. Tests with H, O, and S beams showed no wear after 300 and 600 hr operation. Refrigerated traps are included in the ion source. (D.L.C.)

**31703** A NEW RADIOISOTOPE RENOGRAM EQUIPMENT AND BASIC PROBLEMS OF THE RADIOISOTOPE RENOGRAM. Takeshi Minami, Toyohei Machida, and Akira Ishibashi (Tokyo Jikei Univ.). Radioisotopes (Tokyo), 11: 94-9(Feb. 1962).

The features of radioisotope renogram equipment are described. Use of a wide angle flat field collimator, a discriminator which cuts off the $\gamma$-rays of lower than 300 Kev in order to avoid the influences of $\gamma$-rays of the opposite side, a transistorized ratemeter and use of a two-pen recorder system to make comparison of renograms of both sides easy are features of the equipment. It is suggested that the tracing conditions, such as time constant, range, recording speed, and test material should be noted when one presents a radioisotope renogram. Also, the renogram of the normal kidney or nephrectomized side should show a uniform pattern to eliminate any difficulty in interpretation of the renogram. (auth)

**31704** ASSESSMENT OF BRITTLE FRACTURE STRENGTH IN PRESSURE VESSEL DESIGN. PART I. METALLOPHYSICAL BASES FOR BRITTLE FRACTURE BEHAVIOR. Kurt Schaar (Technischer Überwachungsverein, Essen). Tech. Überwach., 1: 101-8(Mar. 1960). (In German)

The metallophysical bases for brittle fracture behavior are reviewed. The topics discussed are fracture under unilateral stress, multilateral stress in rupture research, the effect of notches in fractures, internal stresses in fracture processes, effect of temperature on fracture, effect of deformation velocities, significance of strange atoms in fracture processes, significance of notched-bar impact tests for the detection of brittle fracture susceptibility of construction materials, transition temperature in the evaluation of brittle fracture tendency, and aging susceptibilities of steels. (J.S.R.)

**31705** ASSESSMENT OF BRITTLE FRACTURE STRENGTH IN PRESSURE VESSEL DESIGN. PART 2. RESULTS FOR STEEL SELECTION FOR STEEL STRUCTURES WITH REGARD TO BRITTLE FRACTURE RISK. Kurt Schaar (Technischer Überwachungsverein, Essen). Tech. Überwach., 1: 159-64(Apr. 1960). (In German)

The effects of the steel selected on the construction are considered with respect to the dangers of brittle fracture

and the emphasis that must be given to brittle fracture behavior in pressure vessels. (J.S.R.)

**31706** ENGINEERING ASPECTS OF ENERGY CONVERSION. W. Kenneth Davis (Bechtel Corp., San Francisco). Prepublication Copy. 7p.

When scientists come face-to-face with engineering problems and recognize their difficulty and the limitations they impose, a productive period of cooperative work by the scientists and engineers leading to solutions of the problems is necessary. Realistic economic considerations become important during this phase. The energy conversion processes under consideration are, of course, in various phases of their development so that one cannot make completely valid general statements. However, most of the processes are now entering the end of the first phase, the phase of scientific optimism, and are approaching the crucial phase where scientists and engineers must work together if useful and practical applications are to be made which will justify the time and money invested in these efforts. (auth)

**31707** DESIGN, PRODUCTION AND TESTING OF NUCLEAR VALVES FOR LIQUID COOLANT REACTORS. A. K. Valen (Valen Engineering Ltd., Montreal). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 26p. $0.50.

The extremely stringent requirements for leaktightness and material behavior of valves to be used in the primary coolant system of a nuclear power plant are summarized. Tables of recommended types of materials are given. Special design features, fabricating methods, and testing procedures are discussed. (A.G.W.)

**31708** THE BASIS AND CONTENT OF A NUCLEAR PRESSURE VESSEL CODE. Elmer O. Bergman (National Engineering Science Co., Pasadena, Calif.). Preprint Paper No. 94. New York, Engineers Joint Council, 1962. 7p.

A committee was appointed by the ASME to develop a nuclear pressure vessel code. The committee membership, policy, and procedure are outlined. The code philosophy and scope are discussed. (A.G.W.)

**31709** CRITERIA AND REQUIREMENTS FOR NUCLEAR PIPING, VALVES AND PUMPS. Joseph A. Klapper (Ebasco Services, Inc., New York). Preprint Paper No. 95. New York, Engineers Joint Council, 1962. 19p.

Nuclear piping is defined as piping designed to contain a fluid whose loss from the system could result in a radiation hazard. Basic components of a nuclear piping system, material requirements and criteria, procedures and acceptance standards for nondestructive testing, and leak testing are discussed. (A.G.W.)

**31710** 1961 TRANSACTIONS OF THE EIGHTH NATIONAL VACUUM SYMPOSIUM COMBINED WITH THE SECOND INTERNATIONAL CONGRESS ON VACUUM SCIENCE AND TECHNOLOGY, OCTOBER 16, 17, 18, 19, 1961, WASHINGTON, D. C. VOLUME 1. Luther E. Preuss, ed. Oxford, Pergamon Press, 1962. 694p.

Proceedings of the Eighth National Vacuum Symposium and the Second International Congress on Vacuum Science and Technology are presented. Topics covered by the 99 papers in Vol. I include: limitations in the attainment of ultra-high vacuum, ultra-high vacuum and limiting parameters, adsorption, adsorption and gettering, sputtering phenomena, sputtering and ion bombardment, mechanical sorption and molecular pumps, diffusion pumps and pump fluids, getter and ion pumping, cryopumping, design and characteristics of vacuum gages, vacuum measurements and units, mass spectrometry, and general vacuum subjects. Separate abstracts were prepared for 50 papers. Three papers were previously abstracted for NSA. (M.C.G.)

**31711** PROCESSES LIMITING THE ULTIMATE PRESSURE IN ULTRA HIGH VACUUM SYSTEMS. A. Venema (Philips Gloeilampenfabrieken, Eindhoven, Netherlands). p.1-7 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Various factors influence the realization of extremely low pressures in vacuum systems and limit the attainable pressure. Some of these are of a physical or chemical nature, but considerations of simplicity and ease of attainment must be taken into account in special cases. The more general aspects are treated and the importance of various factors in different cases is discussed. (auth)

**31712** GAS PERMEATION THROUGH THE VACUUM ENVELOPE. Francis J. Norton (General Electric Research Lab., Schenectady, N. Y.). p.8-16 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The relationships and available values for permeation rate, diffusion constant, and solubility of various gases and solids are discussed. Values are given for walls of glass and metal in differing external environments. Some generalizations can be formulated. True permeation through the wall is due to solution and then diffusion in the wall material. Experiments to measure it must be carefully devised to distinguish its effects clearly from various other gas sources as real leaks, pump backstreaming, gas originally in and on the wall material, electrolysis in glass walls or oxide dissociation effects. Criteria are given for making sure true permeation is being measured. (auth)

**31713** OUTGASSING. R. Jaeckel (Universität, Bonn). p.17-25 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In German)

A summary is given containing data of outgassing rates according to investigations of different authors and from measurements. It shows that outgassing rates depend on the material, on its treatment, and on the conditions of application. In order to define the most favorable conditions for evacuating an ultra-high vacuum apparatus, the fundamental physical processes (physical sorption, chemisorption, diffusion, solubility, etc.) which determine the outgassing process, must be known. Information regarding the lowest attainable pressures in ultra-high vacuum systems can be obtained from the empirical outgassing data in conjunction with the pertinent physical laws. (auth)

**31714** DESORPTION OF ADSORBED GAS AND REEMISSION OF GAS PREVIOUSLY PUMPED BY IONIC PUMPING. J. P. Hobson (National Research Council, Ottawa). p.26-30 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The rate of desorption of adsorbed gas was examined as a function of the activated energy of desorption and the temperature in a simple model. The model was examined for its qualitative approximation to reality and for practical values of the parameters. Recent results on the reemission of gas previously pumped by ionic pumping are

reviewed, and an assessment is presented of the degree to which this source of gas can be reduced. (auth)

**31715** PROBLEMS OF "VERY LARGE SYSTEMS." J. T. Mark and W. G. Henderson (Radio Corp. of America, Lancaster, Penna.). p.31-41 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Very large vacuum systems may be defined as systems requiring special enclosures for their erection and operation, cranes to lift and handle components, and a multiplicity of various pumps for evacuation. The reported problems confronted in building such systems are: materials and the structural integrity of the vacuum wall, dimensional stability around ports and penetrations, designing for differential expansion due to temperature, compatibility of various paralleled pumping units, reliability of components, leak detection and gauging, and abstersion. The Princeton University Stage II Model C-Stellarator vacuum system is taken as a working example of these problem solutions. (auth)

**31716** OUTGASSING RATE OF CONTAMINATED METAL SURFACES. Benjamin B. Dayton (Consolidated Vacuum Corp., Rochester, N. Y.). p.42-57 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Successive evaporation of various molecules from a heterogeneous layer of surface contamination can result in an outgassing rate which is inversely proportional to the time of pumping. A relatively uniform distribution of the activation energies of desorption will result in a sum of the individual outgassing curves for constant desorption energy which appears as a straight line with a slope of minus one on the log–log plot of outgassing rate vs. time of pumping. This line forms an "outgassing barrier" which limits the ultimate pressure in unbaked metal vacuum systems. (auth)

**31717** THE ORIGINS AND COMPOSITION OF THE LIMITING GAS LOAD IN ULTRAHIGH VACUUM SYSTEMS. Imre Farkass and E. J. Barry (Ilikon Corp., Natick, Mass.). p.66-72 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

As a step toward achieving lower pressures as well as a step toward better understanding of ultrahigh vacuum technique, a basic study was made of the origins and nature of the residual gases present when operating in the $10^{-9}$ to $10^{-10}$ Torr range. The relative importance of real air leaks, sealant permeation, surface outgassing, vapor backstreaming, and back diffusion of gas was investigated. The role of each of these factors is discussed and recent research results cited. The meaning of these findings to the design of ultrahigh vacuum systems is pointed out. (auth)

**31718** OUTGASSING DATA FOR SEVERAL EPOXY RESINS AND RUBBERS FOR THE ZERO GRADIENT SYNCHROTRON. F. Markley, R. Roman, and R. Vosecek (Argonne National Lab., Ill.). p.78-85 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Outgassing measurements made on several types of epoxy resins and on several rubbers are presented. Measurements on steel and aluminum are given for comparison. These are all long term measurements of the outgassing over a period of from 0.1 to 500 hr under vacuum. The data were taken by measuring the rate of pressure rise in a closed volume, and the advantages and limitations of the system are discussed. Many detailed data on the outgassing of the nitrilephenolic adhesive used for bonding and sealing the high vacuum chamber of the ZGS machine are presented. (auth)

**31719** ADSORPTION CAPACITIES OF SOME ROOM-TEMPERATURE TRAP MATERIALS. [PART] I. Leonard L. Levenson and Norman Milleron (Univ. of California, Livermore). p.91-7 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (UCRL-6396). (In English)

Some results obtained with a 10-in.-dia. room-temperature isolation trap above a 7 in. oil diffusion pump are presented. The trap material was artificial zeolite. The pump fluid was Convoil "20". After bakeout the fine pressure was $2 \times 10^{-9}$ Torr at an ambient temperature of 21°C. Cooling the trap with liquid nitrogen caused the pressure to fall to $4 \times 10^{-10}$ Torr. Hydrogen, helium, argon, nitrogen, carbon monoxide, carbon dioxide, methane, and n-butane were each bled into the fine pressure volume with the trap at room temperature to study adsorption. Adsorption was observed for only $CO_2$ and n-butane. With the trap at room temperature, evaporating less than 1 $cm^3$ of Convoil "20" into the trap caused the fine pressure to rise to $1 \times 10^{-6}$ Torr. (auth)

**31720** THE INTERACTION OF RARE GAS ATOMS WITH SURFACES. G. D. Halsey, Jr. (Univ. of Washington, Seattle). p.119-25 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

At relatively high temperatures the interaction between the adsorbent and adsorbate molecules is simple enough to permit a virial expansion of the apparent p–V product. If simple rare gas molecules are used, theoretical calculations of some of the virial coefficients can be made for relatively sophisticated potential functions. An accurate gas thermometer was used to investigate low area powder of a defined nature. Some of the information that comes from measurements of this kind are the heat of adsorption of a single atom on a surface, a test of the theories of van der Waals forces, the distance of closest approach of atoms to surfaces, and a way of estimating the area of a well-characterized surface. (auth)

**31721** PHYSICAL ADSORPTION IN ULTRA-HIGH-VACUUM SYSTEMS. J. P. Hobson (National Research Council, Ottawa). p.146-50 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Extremely low pressures ($p \leq 10^{-10}$ Torr) can be achieved by cooling ultra-high-vacuum systems to liquid helium temperatures. The ultimate physical mechanism involved is physical adsorption of the residual gases on the cold surfaces. A discussion is given of the laws of physical adsorption as they apply to ultra-high-vacuum systems, and of various ways in which these laws may be applied in such systems. (auth)

**31722** DESORPTION OF GAS BY PHOTONS. W. J. Lange and H. Riemersma (Westinghouse Research Labs.,

Pittsburgh). p.167-70 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (NYO-9805). (In English)

The release of adsorbed gas by photon bombardment was studied for the system CO on Ni. It was found that the probability is of the order of $10^{-3}$ gas particles released per incident photon for photon energies of a few ev. The effect of outgassing due to bulk heating is shown to be distinguishable from, and negligible in comparison to, the photodesorption process under the experimental conditions. (auth)

**31723** DESORPTION OF NS 22S STAINLESS STEEL BY FLASH-FILAMENT TECHNIQUE IN ULTRA HIGH VACUUM. D. A. Degras (Centre d'Études Nucléaires, Saclay, France), A. Schram, B. Lux, and L. A. Petermann. p.177-85 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Sorption phenomena on NS 22S stainless steel were investigated by the so-called flash-filament technique. Desorption of CO, $H_2$, and $N_2$ was studied, and partial pressures were measured with an Omegatron tube. The principle of the method, the experimental arrangement, and the preparation of the samples are described. Numerous desorption recordings were made for different previous histories of each sample. With the help of some hypothesis, a discussion of the results leads either to an order of magnitude of the energy level of surface adsorption, or to a distribution of the gas density in the bulk of the sample. (auth)

**31724** SOME LOW PRESSURE SORPTION CHARACTERISTICS OF EVAPORATED TITANIUM AND ZIRCONIUM WITH DRY AIR AND OXYGEN. E. J. Zdanuk and S. P. Wolsky (Raytheon Co., Waltham, Mass.). p.188-92 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The room temperature sorption of dry air and oxygen by evaporated titanium and zirconium films was measured by the dynamic capillary flow technique. Films were formed at dynamic ambient pressures of $10^{-3}$ Torr, or less. Speeds of ion gauge pumping were determined and used to obtain true gettering rates. The initial gettering rates, changes in rates with amount sorbed, and sticking coefficients were measured in the pressure range $10^{-4}$ to $10^{-6}$ Torr. Films studied ranged in thickness from about 10 to 1 $\mu g/cm^2$. (auth)

**31725** INVESTIGATIONS CONCERNING BULK GETTERS FROM METALS OF THE IVth A GROUP AND THORIUM. Paolo Della Porta (S. A. E. S. Getters, Milan), Tiziano Giorgi, Salvatore Origlio, and Franco Ricca. p.229-38 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1961. (In English)

The gettering properties of metals of the IVth A group and thorium, as well as some of their alloys, were investigated for a number of gases. Particular attention was paid to the dependence of gettering on temperature. The experimental measurements were carried out at pressures of the same magnitude as encountered in large scale industrial production of electron tubes. The possibility of employing some of the alloys investigated as bulk getters is discussed. The activation conditions and the range of temperatures in which these getters may be satisfactorily employed were considered. Particular attention was paid to those conditions which render these getters stable and give the minimum outgassing within the tube during the preliminary operations. (auth)

**31726** HIGH ENERGY SPUTTERING. O. Almén and G. Bruce (Chalmers Univ. of Tech., Gothenburg, Sweden). p.245-51 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The sputtering rate varies with the type of bombarding ions and with the target material. In order to study details ions of the noble gases neon, argon, krypton, and xenon were used at energies 5 to 65 kev, and many different materials were bombarded. The influence on sputtering from ions trapped in the target was very small and therefore it was possible to arrive at an approximate sputtering equation. One step further was to measure self sputtering ratios which also suit the same equation. In addition, all ions fit into a systematic trend throughout the periodic system of elements. (auth)

**31727** SPUTTERING YIELDS AT MEDIUM AND LOW ENERGIES. R. V. Stuart (General Mills Electronics Group, Minneapolis). p.252-8 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Experimental methods of measuring sputtering yields of polycrystalline metal and semiconductor targets under normally incident low and medium energy mercury and noble gas ion bombardment are described. Measurements are made by immersing targets like large Langmuir probes in a low pressure, high density plasma. Notable features of the yield results are discussed with emphasis on recent results at very low ion energies. (auth)

**31728** A THEORETICAL MODEL OF THE SPUTTERING PROCESS. Don E. Harrison, Jr. (U. S. Naval Postgraduate School, Monterey, Calif.). p.259-64 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

After a discussion devoted to sputtering theories, a semi-quantitative model of the sputtering process is presented in some detail. This model draws upon the older statistical theory, but incorporates important features from the energy-chain mechanism proposed by Silsbee. Qualitatively, the model is consistent with all available sputtering data, and demonstrates why previous quantitative theories have had some limited success. Finally, future theoretical developments and experiments which would clarify the theoretical situation are discussed. (auth)

**31729** ION BEAM METHOD FOR THE STUDY OF THE ANGULAR DISTRIBUTION OF SPUTTERED MATERIAL. Robert D. Knight (International Business Machines Corp., San Jose, Calif.). p.265-70 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

An apparatus is described for determining the intensity distribution of material sputtered from solid surfaces under heavy ion bombardment at any angle of incidence by means of radioactive tracers. A 10 to 30 $mA/cm^2$ rare gas

ion beam was extracted from a modified Von Ardenne source at 1 to 30 kev and allowed to strike a 1.5 mm dia radioactive target. Two Mylar collector strips circularly disposed above the target were removed after each run and cut into sections corresponding to 10° angular increments and counted in a NaI well counter. The apparatus can be adapted to produce beams of many different ions. (auth)

**31730** THE SPUTTERING OF COPPER BY $N_2^+$ AS A FUNCTION OF PRESSURE AND TEMPERATURE. Thomas W. Snouse and Michel Bader (National Aeronautics and Space Administration, Moffett Field, Calif.). p.271-4 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Sputtering yields of copper under bombardment by mass-analyzed beams of $N_2^+$ were measured at 3 kev as a function of the target chamber background pressure ($3 \times 10^{-5}$–$5 \times 10^{-8}$ Torr) and the target temperature (60 to 475°C). A specially designed ultra-high vacuum system made it possible to control the background pressure independently of the beam current. The target temperature at the beam spot was controlled independently of the beam current density. The results are discussed in terms of sputtering mechanisms. (auth)

**31731** POSITIVE ION BOMBARDMENT OF METAL SURFACES. J. S. Colligon and J. H. Leck (Univ. of Liverpool). p.275-80 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Experimental results are reported on the sorption of neon, argon, and krypton ions by molybdenum, platinum, and tungsten surfaces. The measurements were made on ribbon targets using monochromatic ion beams with energies up to 3 kev. Observations were also made upon the replacement of a sorbed gas by bombardment with ions of a different gas. An analysis showed the results to be consistent with the mechanisms of sputtering and ion penetration and enabled a quantitative estimate of the depth distribution of the incident ions to be made in terms of the sputtering coefficients of the metals. (auth)

**31732** THE DESORPTION OF IONICALLY TRAPPED ARGON FROM TUNGSTEN. E. V. Kornelsen (National Research Council, Ottawa). p.281-6 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

A thoroughly clean tungsten wire target was bombarded with singly charged mono-energetic argon ions in the energy range 80 to 4000 ev. The argon atoms trapped in the tungsten were thermally desorbed into a known volume containing no significant argon pumps. Two modes of heating were used: rapid flashing to 2400°K, and uniform slow heating rate (50°K/sec) to 2400°K. The former experiments yielded values of ion sticking probability and entrapment saturation numbers; the latter gave activation energies of desorption. Four desorption peaks were observed whose amplitudes depended on the bombarding ion energy, but whose temperatures did not. (auth)

**31733** A MAGNETICALLY SUSPENDED MOLECULAR PUMP. C. E. Williams and J. W. Beams (Univ. of Virginia, Charlottesville). p.295-9 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The alloy steel rotor of a bakeable molecular pump was magnetically suspended inside a stainless steel vacuum chamber and spun by a rotating magnetic field. Operational data are given including ratios of the pressure on the high side to the low side of the pump as a function of rotor speed and clearance between rotor and stator. Pumping speeds of the order of 10 *l.*/sec, pressures of $4 \times 10^{-10}$ Torr, and pressure ratios of $10^8$ were obtained. The experimental data are compared with a theory worked out for the pump. (auth)

**31734** HIGH VACUUM WITH THE POLYPHENYL ETHERS–A SELF-CONTAINED TECHNOLOGY. K. C. D. Hickman (Rochester Inst., New York). p.307-14 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The polyphenyl ethers, consisting of chains of benzene radicals interbonded by oxygen are useful in high vacuum because of their exceptional stability. The isomer mixture, bis (phenoxy-phenoxy)-phenyl ether, has a vapor pressure at 25°C of ~$10^{-9}$ Torr and yields vacuums approaching $10^{-9}$ Torr in the unrefrigerated condensation pump. Applied to gaskets, valves, and joints or as a coating to large inside metal surfaces they enable ultra high vacuums to be induced rapidly and economically on any desired scale of operation. Five examples, with quantitative data are described, ranging from the single stage glass pump to an oil-sealed container evacuated by fractionating metal pumps. (auth)

**31735** EVALUATION OF A HIGH-TEMPERATURE FUNCTIONAL FLUID IN A CONVENTIONAL DIFFUSION PUMPING SYSTEM. Thomas H. Batzer (Univ. of California, Livermore). p.315-19 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (UCRL-6577-T). (In English)

A high temperature fluid "Monsanto OS–124" was tested in a PMC 720 diffusion pump. The fluid was evaluated on the basis of its performance in a conventional system with a few modifications. The effects of variations in the boiler input and pump barrel temperature were noted. The base pressure and speed with a one bounce baffle operated at various temperatures were checked. The composition of the residual gas at the base pressure was determined with a mass spectrograph. And of great importance to the Sherwood Project, the effect on the fluid of a large hydrogen throughput was checked. (auth)

**31736** A HYPOTHESIS CONCERNING LIMITATIONS OF DIFFUSION PUMPS. Patrick B. Kennedy (Univ. of California, Berkeley). p.320-6 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (UCRL-9782 and Rev.). (In English)

An examination was made of the wide discrepancy between theoretical and actual performance of diffusion pumps and of the reasons adduced for this discrepancy. A hypothesis is offered, according to which the relatively high pressures persisting on the high-vacuum side of diffusion pumps result from the backstreaming of large numbers of molecules carried on compression waves originated by eruptive boiling. This hypothesis accounts for the relative

ineffectiveness of baffles and for several other previously unexplained phenomena. Evidence supporting the hypothesis is given, remedial measures are suggested, and implications for many vacuum applications are briefly outlined. (auth)

**31737** ON AN OIL SELF-PURIFYING DIFFUSION PUMP SYSTEM. Hiroo Kumagai (Tokyo Univ.). p.327-32 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

A special oil diffusion pump system was tested in which two well fractionating pumps are used in series and vacuum pipe lines are specially designed. In the system, impurities of diffusion pump oils are quickly removed and good vacuum is obtained with no refrigerated trap and the back streaming of oils is extremely suppressed. Using this system, the 63 in. variable energy cyclotron is operated with no refrigerated trap, getting good vacuum and great stability. The system is also applied for a pumped klystron using an oxide cathode and the life of the cathode is longer than 500 hr. (auth)

**31738** TESTING PERFORMANCE OF DIFFUSION PUMPS. M. H. Hablanian and H. A. Steinherz (NRC Equipment Corp., Newton Highlands, Mass.). p.333-41 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Measurement techniques and experimental results are presented for the major performance criteria of oil diffusion pumps. Special emphasis is placed on new developments including the diffusion pump oils and zeolite traps. Statistical variations observed in testing groups of pumps of the same design are presented. (auth)

**31739** PROGRESS ON OPTIMIZATION OF OIL DIFFUSION PUMP SYSTEMS FOR ULTRA-HIGH VACUUM. [PART] III. Norman Milleron and Leonard L. Levenson (Univ. of California, Livermore). p.342-4 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (UCRL-6407). (In English)

Boiler and top jet designs are presented for use with the ultra-low-vapor-pressure oils for diffusions pumps reported earlier by Hickman. The boiler design has several unique features. It eliminates eruptive boiling, creates superheated vapor at 300°C and maintains liquid oil below 100°C, starts and stops producing a vapor stream in 5 sec, and permits air to be introduced without damage. The jet design provides high vapor density, yielding Ho factors >0.85 for nitrogen and a fore pressure tolerance >1 Torr. Over-all pump height can be numerically smaller than the diameter of the top of the pump. (auth)

**31740** PRELIMINARY PUMPING RESULTS WITH PENNING-TYPE DISCHARGES SUPPORTED ON CONDENSABLE METAL VAPORS. Norman Milleron (Univ. of California, Livermore). p.365-8 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (UCRL-5598). (In English)

A Penning discharge, supported on a pseudo gas of metal vapor, functions as an ion-getter pump. Liquid metal that is molten at 60°C and has vapor pressure less than $10^{-12}$ Torr is used as cathode material; it is vaporized continuously by a tungsten wick. This metallic vapor, condensable within line of sight, is used to sustain a Penning discharge at constant current independent of diminishing gas pressure outside the discharge. The pumping effect observed with this metallic vapor-supported discharge is attributed to interaction between ions and the liquid cathodes. Energetic beams of ions or neutrals may be caught by liquid metal targets. (auth)

**31741** ONE YEAR OF OPERATING EXPERIENCE WITH 70 GETTER-ION PUMPS. C. L. Gould and R. A. Dryden (Brookhaven National Lab., Upton, N. Y.). p.369-73 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (BNL-5719). (In English)

The vacuum system for the 30 Bev alternating gradient synchrotron is discussed. The operating and maintenance experience on a system using over seventy getter-ion pumps for one year is discussed. Down-time, component life, technician training, remote control, and operation are emphasized. (auth)

**31742** SOME EXPERIMENTAL DATA ON PARAMETER VARIATIONS WITH THE TRIODE GETTER-ION PUMP. Allen R. Hamilton (Consolidated Vacuum Corp., Rochester, N. Y.). p.388-94 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The principle of operation of the triode cold-cathode getter-ion pump is described. Experimental data are presented showing the effects of variations in voltage and magnetic field on pumping speed. Also a series of experiments are described in which electrode potentials were adjusted to simulate various diode and triode pump configurations. Mass spectrographic data are presented, comparing the pumping efficiency and re-emission of various gases when sputter cathodes of titanium, tantalum, zirconium, and niobium are used. (auth)

**31743** A CATALYTIC METHOD FOR CRYOPUMPING HYDROGEN. Jack Grobman (National Aeronautics and Space Administration, Cleveland). p.421-5 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Experiments were conducted to examine the feasibility of cryopumping hydrogen by means of an intermediate catalytic surface reaction. Hydrogen was reacted with oxygen in vacuo on a palladium-coated alumina catalyst. The water vapor formed by this reaction was condensed on a liquid-nitrogen-cooled surface. Cryopumping was observed at pressures as low as about 0.4 $\mu$ mercury. The application of this method of pumping to the design of vacuum chambers for testing electric thermal rockets using hydrogen propellant with throughputs of the order of $6 \times 10^6$ $\mu$l./sec is discussed. (auth)

**31744** AN IONIZATION GAUGE FOR MEASUREMENT OF ULTRA-HIGH VACUA. A. Klopfer (Philips Zentrallaboratorium G.m.b.H., Aachen). p.439-42 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

A hot cathode ionization gage with an electrode structure similar to that of an omegatron is described. The ionizing

electron beam is focused by an axial magnetic field. The electrons traverse the ionization chamber and are finally collected by a trap outside the ionization chamber. The ion collector is arranged inside the ionization chamber at a place where it cannot be hit by x rays emitted from the electron trap. All ions formed by the electron beam inside the ionization chamber move to the ion collector under the influence of an applied electrostatic field. At pressures lower than $10^{-2}$ Torr a linear relationship exists between pressure and ion current. The low pressure limit could not be determined previously. Down to $10^{-11}$ Torr no indication of a limitation was found. (auth)

**31745** A BAYARD-ALPERT TYPE IONIZATION GAUGE WITH A LOW X-RAY LIMIT. A. Van Oostrom (Philips Gloeilampenfabrieken, Eindhoven, Netherlands). p.443-50 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

An ionization gage for ultra-high vacuum work is described. The x-ray limit of this gage was lowered by increasing the sensitivity of the gage for low energy electrons and by reducing the absorption of x rays by the ion collector wire. It is shown that this can be achieved by choosing a special grid structure and by applying a proper potential distribution inside the grid volume. The calculated x-ray limit of such a gage is below $10^{-12}$ Torr. (auth)

**31746** THE X-RAY LIMIT IN IONIZATION GAUGES. H. J. Schuetze and H. W. Ehlbeck (Telefunken, Ulm, Ger.). p.451-9 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

For the x-ray limit in ionization gages the equation $p_{min} = 10\ k_x/k_g$ was obtained with $k_x$ the photoelectron constant and $k_g$ the gas ion constant. A theoretical analysis of the quantity $k_x$ was performed taking into account the x-ray emission due to electron bombardment of the electron collector and the release of photoelectrons at the ion collector. It is shown that $k_x$ is proportional to the $n^{th}$ power of the electron collector voltage in satisfactory agreement with experimental results. The exponent n depends mainly on the properties of the ion collector material and falls between n = 1 and 2. The constant of proportionality is dependent upon the tube geometry and to a lesser degree upon the electron collector material. Experimental investigations were carried out with receiving tubes, ionization gages, and specially assembled test tubes. Methods to reduce the x-ray limit are discussed. (auth)

**31747** FURTHER DEVELOPMENTS IN THE HOT-CATHODE MAGNETRON IONIZATION GAUGE. J. M. Lafferty (General Electric Research Lab., Schenectady, N. Y.). p.460-3 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

A hot-cathode magnetron ionization gage capable of measuring pressures as low as $10^{-14}$ Torr was previously described. The low pressure limit of this gage was extended by the addition of an electrostatic lens system that focuses the ions on the first dynode of an electron multiplier. This resulted in further reduction of the x-ray photocurrent and an increase in output current. Photoelectric emission caused by light from the hot filament was reduced by the use of a lanthanum boride cathode which operates at 675°C. Measurements of sensitivity and x-ray photocurrent indicated that this arrangement should have a linear response down to pressures of $10^{-15}$ Torr with an output current of the order of $10^{-11}$ A. (auth)

**31748** A VACUUM MANOMETER USING ULTRAVIOLET LIGHT. Igor Alexeff (Oak Ridge National Lab., Tenn.). p.472-5 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

An ultra-high vacuum manometer which theoretically may measure vacua to better than $10^{-13}$ Torr is discussed. The device uses a special Geiger–Mueller counter tube. This tube counts ultraviolet photons from the electron bombarded rest gas. The device is also a gas analyzer when equipped with a set of narrow band ultraviolet transmission filters. The device was tested successfully as a hydrogen leak detector. Theoretical calculations, experimental results, and references are presented. (auth)

**31749** GENERAL OBSERVATIONS ON HOT FILAMENT ION GAUGE OPERATION IN HOMOGENEOUS MAGNETIC FIELDS. G. D. Martin, Jr. (Princeton Univ., N. J.). p.476-82 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (MATT-80). (In English)

Ion gage operation in magnetic fields is sometimes unavoidable. Bayard–Alpert type, high pressure, and conventional ion gages were operated in a homogeneous static magnetic field of 0.2 weber/$m^2$, and in pulsed fields as high as 1.5 webers/$m^2$ in several orientations. The effect of the magnetic field on ion and emission currents was noted and compared with that expected from qualitative theoretical considerations. Satisfactory agreement was found. Operation is feasible with proper orientation. (auth)

**31750** ACCURATE CALIBRATION OF VACUUM GAUGES TO $10^{-9}$ TORR. Jonathan R. Roehrig and John C. Simons, Jr. (National Research Corp., Cambridge, Mass.). p.511-18 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Apparatus for the accurate calibration of vacuum gages at pressures from $10^{-3}$ to $10^{-9}$ Torr was constructed. The system involves a cascade of differentially-pumped stages with carefully defined orifices. Operating in the molecular flow region, a low pressure at the gage under test can be referred to a McLeod gage operating at a higher pressure in a range favorable to it. Pressure ratios up to $10^5$ between the McLeod gage and test gage were obtained. (auth)

**31751** A COMPARISON OF THE PARTIAL-PRESSURE-MEASURING APPARATUS TOPATRON AND OMEGATRON. G. Reich and H. G. Noeller (Bayental Hochvakuum, Cologne). p.560-6 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In German)

The Topatron, a high-frequency spectrometer, with a measuring range of $10^{-3}$ to $10^{-7}$ Torr and the Omegatron, with a measuring range of $10^{-5}$ to $10^{-11}$ Torr, complement each other in their uses. Measurements are presented showing the interdependence of resolution and sensitivity of the two instruments. The elimination of disturbances due to background effects and harmonics is discussed. (auth)

**31752** RAPID SCANNING R. F. MASS SPECTROMETER. H. W. Ehlbeck, J. Ruf, and H. J. Schuetze (Telefunken, Ulm, Ger.). p.567-72 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Sec-

ond International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

An automatically rapid scanning r-f mass spectrometer for the investigation of materials processing, especially the evaporation of metals, was developed. The assembly of the spectrometer tube operating in the pressure range from $10^{-9}$ to $5 \times 10^{-4}$ Torr with a resolving power of $(M/\Delta M)_{0.5} > 100$ is described. Using these capabilities a simple recorder plot is advantageous for the evaluation of the gas components evolved or absorbed during the processing of materials. A recording time of 20 sec was achieved for the total mass range from M = 2 to M = 350. Details on the mode of operating the tube and the necessary circuit arrangements are outlined. (auth)

**31753** THE MASS FILTER PARTIAL-PRESSURE VACUUM GAUGE. Karl-Georg Guenther and Walter Haenlein (Siemens-Schuckertwerke A. G., Nuremberg). p.573-80 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

A description is given of the construction and properties of a partial-pressure vacuum gage which operates on the principle of the so-called mass filter. By the selection of suitably adapted ion sources the measuring cell can be employed in a pressure range extending from a maximum of $5 \times 10^{-3}$ to approximately $10^{-10}$ Torr. The incorporation of various analyzer systems makes possible for the detectable mass numbers an interval of m = 1 to 200 with a resolving power of up to $m/\Delta m = 100$. The versatility of the arrangement is illustrated by the fact that it is possible, depending on the cell equipment, to carry out measurements in a range extending from sensitive ultra-high vacuum to the relatively high pressures encountered in numerous technical applications. (auth)

**31754** THE ANALYSIS OF $10^{-11}$–$10^{-13}$ $cm^3$ STP NOBLE GAS SAMPLES BY MASS SPECTROSCOPY. L. F. Herzog (Pennsylvania State Univ., University Park and Nuclide Analysis Associates, State College, Penna.), T. J. Eskew, and R. L. Erwin. p.581-91 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The use of "static" (closed) vacuum systems has become mandatory in certain geophysical studies, where small gas samples must be conserved. Such work requires vacuum systems that are extremely clean and well degassed, and capable of being baked-out at temperatures of 250 to 400°C; without sample, such systems must hold at pressures of the order of $10^{-9}$ Torr. Both glass and metal systems were used for such work. The systems presently in use are described, with emphasis on materials, joining techniques, gaskets, valves, getters, and pumps. The residual gas spectra encountered are described. These mass spectrometer data are compared with total pressure indications from ion gages of various kinds. (auth)

**31755** MASS-SPECTROMETER INVESTIGATIONS IN ULTRA-HIGH VACUUM SYSTEMS. W. K. Huber and E. A. Trendelenburg (A. G. fllr Hochvakuumtechnik und Dünne Schichten, Balzers, Liechtenstein). p.592-7 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

A mass spectrometer that works on the principle of crossed electrical and magnetic fields, as devised by Bleakney and Hipple, is described. The spectrometer is bakeable and is intended for analyzing the composition of the residual-gas atmosphere in ultra-high vacuum systems. The residual-gas atmosphere in ultra-high vacuum systems, operated with oil-diffusion pumps, was studied with the aid of this mass spectrometer in relation to the type and temperature of the cathode used. The mass spectra obtained are discussed. (auth)

**31756** RESIDUAL GASES IN METAL VACUUM SYSTEMS. Masami Michijima (Kobe Univ. of Mercantile Marine, Japan), Jun Okano, Atsushi Fujinaga, and Koreichi Ogata. p.598-605 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

Mass spectrometric investigations of residual gas in a stainless steel enveloped mass spectrometer, evacuated with a titanium-getter ion pump, were carried out. Partial pressure of nitrogen of $10^{-13}$ Torr could be measured by means of a secondary electron multiplier which served as an ion detector of the mass spectrometer. Mass 2 ($H_2$) and 28 ($N_2$ + CO) were observed to be the dominant constituents of the residual gas. It was also found that a considerable amount of argon existed in the residual gas. Hydrocarbon found in the residual gas could be minimized rapidly by baking the system to a temperature of about 200 to 300°C. (auth)

**31757** RESIDUAL GASES DURING OPERATION AND LIFE-TESTING OF POWER KLYSTRONS. Lowell Noble and Robert K. Waits (Eitel-McCullough, Inc., San Carlos, Calif.). p.606-11 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The gases present during exhaust processing, operation, and life testing of high-power klystrons were analyzed using a Diatron mass spectrometer. During bakeout at 500°C, hydrogen, water, carbon dioxide, and methane were evolved. Carbon dioxide, methane, and carbon monoxide predominated during cathode conversion. Electron bombardment of internal tube parts released carbon monoxide. After seal-off, the pressure was $10^{-7}$ Torr (carbon monoxide, methane, hydrogen). One hundred hours of klystron operation reduced the pressure to $10^{-9}$ Torr (carbon monoxide, hydrogen). Microleaks in a sealed klystron resulted in the appearance of argon; neither oxygen nor a mass 28 increase were detected. The argon disappeared during klystron operation. (auth)

**31758** $H_3^+$ AND $H_2D^+$ IONS IN THE OMEGATRON. George Băjeu and George Comsa (Inst. for Atomic Physics, Bucharest). p.617-24 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

The appearance of an unusually large $H_3^+$ ion current in an omegatron, drowning the $HD^+$ current at low deuterium concentrations, at $10^{-4}$ to $10^{-7}$ Torr hydrogen pressures, is discussed. An experimentally checked relation is presented $I_{H_3^+} = (2p_{H_2}^2)/(A)\ [\sqrt{(1 + (A\mathcal{F}_{H_3^+}K)/(p_{H_2}))} - 1]\ \exp(-b_{H_3^+}p)$ where A, $\mathcal{F}_{H_3^+}$, and K are constants, $p_{H_2}$ the hydrogen pressure, and p the total pressure. The high yield of $H_3^+$ ion formation in the omegatron suggested the idea of detecting small deuterium concentrations by measuring the current of $H_2D^+$ ions, which appear at least in three different collision processes. Deuterium can be detected down to natural concentrations and even lower ones. (auth)

**31759** ULTRA-HIGH VACUUM ULTRAVIOLET MONOCHROMATOR. L. Marton, J. A. Simpson, J. A. Suddeth, and L. B. Leder (National Bureau of Standards, Washington, D. C.). p.633-9 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

A 1 m, normal incidence vacuum ultraviolet monochromator having a sample chamber pressure of approximately $10^{-9}$ Torr is described. The entrance and exit slits are fixed in space and on Rowland circle. Wavelength is scanned by moving the grating along the circle. This arrangement requires the center of the Rowland circle to move. All moving parts are external to the vacuum chamber. The high vacuum conditions are obtained by several stages of differential pumping from the lamp housing to the sample chamber. The entire monochromator is of stainless steel with welded joints. Interesting vacuum features are the flange design, liquid nitrogen traps, and rotary seal. (auth)

**31760** PROBLEMS ASSOCIATED WITH LOW PRESSURE ION ACCELERATION. A. H. Frentrop and H. Sherman (Schlumberger Well Surveying Corp., Ridgefield, Conn.). p.652-5 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1962. (In English)

A small sealed ion accelerator neutron source was developed which, using the deuterium-tritium reaction, produces up to $10^9$ neutrons/sec. The tube was developed for oil well logging purposes where limited amounts of power are available and high ambient temperatures are encountered. The accelerator requires less than 100 W of power and operates at ambient temperatures up to 150°C. The accelerator tube includes the conventional elements of a laboratory accelerator: a gas reservoir, an ion source, an accelerating gap, and a target. The gas reservoir is a zirconium hydride filament and the ion source is a Penning type source. A study was made of the zirconium hydride system at low pressure and low atomic ratio. All three isotopes of hydrogen were used in the measurement. A comparison of our results and the data previously published is made. An account of the acceleration of ions at a pressure of one to twenty microns is given. An explanation of the effects observed is given in terms of charge exchange, secondary electron emission, and ionization. (auth)

**31761** 1961 TRANSACTIONS OF THE EIGHTH NATIONAL VACUUM SYMPOSIUM COMBINED WITH THE SECOND INTERNATIONAL CONGRESS ON VACUUM SCIENCE AND TECHNOLOGY, OCTOBER 16, 17, 18, 19, 1961, WASHINGTON, D. C. VOLUME 2. Luther E. Preuss, ed. Oxford, Pergamon Press, 1962. p.670-1351.

Proceedings of the Eighth National Vacuum Symposium and the Second International Congress on Vacuum Science and Technology are presented. Topics covered by the 102 papers in Vol. II include: vacuum metallurgy, electron beam melting and gas evolution, production and measurement of thin films, vaporizing sources and lyophilization, leaks and gas flow, vacuum systems, space simulation, components, and refrigeration and baffling. Separate abstracts were prepared for 24 of the papers. Two papers were previously abstracted for NSA. (M.C.G.)

**31762** FUSION WELDING OF BERYLLIUM IN A VACUUM ATMOSPHERE. W. T. Hess, H. J. Lander, S. S. White, and L. McD. Schetky (Alloyd Corp., Cambridge, Mass.). p.679-84 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

Both hot-rolled and pressed-and-sintered beryllium were successfully fusion welded utilizing an electron beam as a heating source. It was found that with proper heat input and operating pressure conditions, leak tight beryllium weldments having sufficient tensile strengths in the fusion, heat-affected, to match the baseplate zones could be accomplished. Thus, vaporization and thermal cracking limits for an operating vacuum and power input could be defined for a particular specimen and quench block geometry. Repair welding of cracks or voids was not found possible for specimens exposed to air prior to repair welding attempts, presumably because of air entrapment within the crevices. (auth)

**31763** STUDIES ON ELECTRON-BEAM WELDING. G. Ito, H. Suzuki, T. Hashimoto, and F. Matsuda (National Research Inst. for Metals, Tokyo). p.693-8 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

With an experimental electron-beam welding machine (50 kv × 30 ma, 1.5 kw welding power), effects of welding conditions on welding characteristics such as weld appearance, penetration, and soundness of weld were studied with specimens of zirconium, Zircaloy-2, titanium, stainless steel, niobium, tantalum, and molybdenum. Mechanical properties, microstructures of welded joints and corrosion resistance against high temperature and high pressure water (320°C, 116 atm) were investigated as compared with TIG specimens welded in a controlled atmosphere chamber. (auth)

**31764** EXPERIENCE WITH AN ELECTRON BEAM MELTING FURNACE. Clifton B. Sibley (NRC Equipment Corp., Newton, Mass.) and Maurice L. Torti. p.714-21 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

A 60 kw remote gun, electron beam melting furnace was used in the production of tantalum, niobium, and other metals for more than a year. This experience showed the economics of the process and has provided valuable vacuum equipment design data. Specific metallurgical data are presented including chemical analyses, melting rates, yields, and physical properties of various metals. (auth)

**31765** ELECTRON BEAM MELTING WITH MULTIPLE GUNS. H. Gruber, H. Stephan, W. Dietrich, and R. Lesser (W. C. Heraeus G.m.b.H., Hanau/Main, Ger.). p.722-31 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

Principles of electron beam melting under high vacuum are discussed. The ring beam system and electron gun system are outlined. The electron beam melting furnace with multiple separately evacuated guns is described. Advantages of guns over ring beam system are listed. Different methods of melting with electron guns (addition melts, drip melts etc.) are described. Vacuum problems of electron beam melting are discussed. Remarks on dimensioning of pumping system to achieve high vacuum are included. General thoughts on degassing of reactive metals under high vacuum are given. Data on the purification of

niobium and tantalum through electron beam melting are presented. Application of electron beam melting for production and laboratory work is discussed. (auth)

**31766** A SKULL FURNACE AND ITS OPERATION. C. Hayashi, S. Kashu, and T. Tsuchiya (Japan Vacuum Engineering Co. Ltd., Yokohama, Japan). p.744-8 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

Development in design and operation of a skull furnace for casting a uranium or uranium alloy fuel rod is described. A newly designed bottom pouring crucible incorporated with a centrifugal casting device was used for uranium casting though tilt pouring seemed preferable for many other uses. Eight pieces of ½ in. o-d by 6 in. long rods were cast in a vacuum less than 1 m Torr using U-3% Zr and U-1% Nb consumable electrodes. There was no contamination and segregation in the cast shape though density was slightly less than theoretical value which may be improved by heating up the mold. (auth)

**31767** VACUUM HOT PRESSING OF REFRACTORY MATERIALS. E. W. Hoyt (General Electric Co., Pleasanton, Calif.). p.788-90 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

An induction heated vacuum hot press of simple design was constructed and used for the past two years at this laboratory. It proved to be an extremely versatile tool for consolidating a wide variety of refractory materials for research investigations. The equipment capabilities are: temperatures in excess of 2500°K at vacuum of the order of $10^{-4}$ Torr and compacting pressures of 200 to 300 kg/cm$^2$ applied to powders contained in a graphite die. (auth)

**31768** STRESS AND STRESS ANISOTROPY IN IRON FILMS. J. D. Finegan and R. W. Hoffman (Case Inst. of Tech., Cleveland). p.935-42 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

The tensile stress and stress anisotropy in iron films from 200 to 1000 Å thick were measured at various angles of incidence of the depositing atoms. The ratio of the minimum to maximum stress decreased as the angle of incidence increased. The maximum tension was normal to the plane of incidence. At 36.5°, the stress was about $10^{10}$ dyn/cm$^2$ and decreased with increasing thickness except for a narrow peak at about 700 Å. The stress ratio at 36.5° decreased from 0.94 for a film 216 Å thick to about 0.84 at 700 Å and then increased to 0.89 at 1030 Å. (auth)

**31769** A NEW DEPOSITION TECHNIQUE FOR REFRACTORY METAL FILMS. M. S. P. Lucas, C. R. Vail, W. C. Stewart, and H. A. Owen (Duke Univ., Durham, N. C.). p.988-91 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

As part of an investigation to produce high-stability corrosion-resistant superconducting films the vacuum-arc process was modified in such a manner that it may be used in the laboratory for the deposition of high-purity specular refractory metal films. Deposition rates of greater than 50 Å/sec were obtained for tantalum at a distance of 4 cm from the source. To date, niobium, tantalum, vanadium, and iron films were produced. What is believed to be a different vacuum-arc phenomenon was observed. (auth)

**31770** PRODUCTION OF THIN SELF-SUPPORTING CARBON FILMS. B. J. Massey (Oak Ridge National Lab., Tenn.). p.992-4 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

Thin self-supporting carbon films 50 to 10,000 Å thick and up to 15.5 cm$^2$ in area were prepared from a carbon arc in an evacuated system. Methods for removing the carbon films from the substrate are discussed. Thicknesses were determined by using a multiple-beam interferometer. (auth)

**31771** HIGH SENSITIVITY HELIUM MASS SPECTROMETER LEAK DETECTION. M. Doctoroff, S. S. Grossel, and D. W. Oblas (Vacuum-Electronics Corp., Plainview, N. Y.). p.1081-5 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

An experimental high sensitivity helium mass spectrometer leak detection system is described. The instrument incorporates a highly effective ion source, a two-stage analyzer tube, and a differentially pumped source region. The minimum-detectable-leak of this system is $5 \times 10^{-13}$ atm cm$^3$/sec (helium). A concept, the Sensitivity Figure of Merit, is presented which permits a more complete evaluation of an instrument. (auth)

**31772** STANDARD LEAKS AND THEIR CALIBRATION BY CONSTANT PRESSURE CHANGE IN VOLUME TECHNIQUES. Maurice K. Laufer (Sandia Corp., Albuquerque, N. Mex.). p.1086-90 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

Standard leaks are calibrated using $p(\Delta V/\Delta t)$. For leakage rates $>10^{-6}$ Torr-*l.*/sec a valved off evacuated volume is used for $\Delta V$. For rates in range $10^{-10}$ to $10^{-6}$ Torr-*l.*/sec $\Delta V$ is obtained by the mechanical expansion of metal bellows. The pressure is the same at the beginning and end of the time interval $\Delta t$ for both cases. Because of its nonpumping characteristic, a Knudsen vacuum gage is used to determine p in the calibration of the slower leaks. Standard leaks having rates of $10^{-6}$ to faster than $10^{-3}$ Torr-*l.*/sec and normal calibration periods of 12 months are described. (auth)

**31773** CORRELATIONS BETWEEN LEAK RATE AND SOME PHENOMENA OBSERVED IN METAL TO METAL CONTACT. G. Armand, J. Lapujoulade, and J. Paigne (Commissariat à l'Énergie Atomique, Saclay, France). p.1991-9 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

Correlations between the leak rate and phenomena observed in metal to metal contact were investigated using a cylindrical ring placed between two flanges. To obtain a leak rate of less than $10^{-10}$ atm/cm$^3$/sec, the required crushing-stress must correspond at least to the yield strength of the cold-worked material. Moreover, there seems to exist a connection between this required force and the electrical contact resistance. The results are applied to the design of metallic vacuum gaskets. (auth)

**31774** PRODUCTION LEAK TESTING OF LARGE PRESSURE VESSELS. J. G. King (Sandia Corp., Albuquerque, N. Mex.). p.1100-5 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

A method and apparatus for dynamic leak measurement of large pressure vessels are described. The method as used in production was used on vessels from ¼ to 30 cubic feet of volume, having leakage rates from $1 \times 10^{-2}$ to $2 \times 10^{-5}$ atm/cm$^3$/sec. Techniques and hardware improvements which made this range possible are discussed, as well as the factors which caused them. Some of the sources of error and their elimination are considered. Data are provided indicating the practicality of this method as a production inspection tool for pressure vessels, both large and small. (auth)

**31775** RING VACUUM SYSTEM ZERO GRADIENT SYNCHROTRON ARGONNE NATIONAL LABORATORY. J. Moenich and R. Trcka (Argonne National Lab., Ill.). p.1133-9 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

The Ring Magnet Vacuum Pumping System consists of sixteen 32 in. oil diffusion pumps, modified by expanding the pump casing to accommodate a 48 in. dia "Z" type chevron baffle, mechanically refrigerated. Outgassing data and high impedance characteristics for the "Spacemetal" inner chamber (average pressure $2 \times 10^{-6}$ Torr) coupled with a restriction of pumping locations prelude the description of the differential pumping system, pump down procedure, operational controls, and protective devices. Two closed ring piping manifolds for the vacuum system, operating as common headers for the pumps, permit interchangeability of equipment, performance reliability, and sufficient flexibility to conform to accelerator operation. (auth)

**31776** RING MAGNET VACUUM CHAMBER SYSTEM OF THE ARGONNE NATIONAL LABORATORY ZERO GRADIENT SYNCHROTRON. W. B. Hanson (Argonne National Lab., Ill.). p.1140-50 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

The development and fabrication programs of the Zero Gradient Synchrotron vacuum chamber system are reviewed. The period from which the basic parameters of the synchrotron vacuum chamber were laid through the actual fabrication which is now in process is covered. The inner vacuum chamber is unique in its use of a light-weight aircraft material called "Spacemetal." The problems in minimizing eddy currents caused by the rapidly changing magnetic field vacuum sealing, and construction of 54 ft long chambers are discussed. The outer vacuum chamber is formed by sealing the synchrotron magnet blocks so that a rough vacuum of less than 1 mm can be maintained. (auth)

**31777** ULTRA HIGH VACUUM SYSTEM FOR A LARGE ELECTROMAGNETIC ISOTOPE SEPARATOR. R. J. Connor, R. S. Buritz, and T. von Zweck (High Voltage Engineering Corp., Burlington, Mass.). p.1151-3 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

A large, all metal vacuum system capable of being baked at 450°C was built for high purity separation of short-lived isotopes. The 22 ft long system is pumped with oil diffusion pumps through high conductance low loss liquid nitrogen traps. Gold-wire seals are used for all demountable joints. Large aperture straight through bakeable vacuum valves are used for isolating the ion source and collector. Thus, pressures less than $10^{-6}$ Torr are achieved in 5 min after introducing a sample. Design and operational data are presented. (auth)

**31778** EXPERIENCE WITH THE VACUUM EQUIPMENT FOR THE CERN 25 Gev PROTON-SYNCHROTRON. G. L. Munday (CERN, Geneva) and G. Zinsmeister. p.1154-7 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

The basic concept of the vacuum pumping equipment and a brief outline of the whole vacuum system of the CERN 25 Bev proton synchrotron are given. Test requirements and the results obtained are commented on. Remarks are made on the operational experience gained with the accelerator in service for nearly two years. Machine time lost due to pumping equipment faults proved negligible. (auth)

**31779** A PORTABLE, HIGH-SPEED ULTRA HIGH VACUUM SYSTEM. Richard E. Honig (RCA Labs., Princeton, N. J.). p.1166-74 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

A portable all-metal ultra-high vacuum system was designed and constructed which achieves $1 \times 10^{-10}$ Torr at a pumping speed of 800 *l*/sec, and is free of hydrocarbon contamination. A sorption pump provides the forevacuum for a 25 *l*/sec ion-getter pump which evacuates the system to below $10^{-8}$ Torr. The ultimate pressure of $1 \times 10^{-10}$ Torr is obtained by a liquid-helium pump whose air speed is 800 *l*/sec. An omegatron (resolving power ~45) analyzes the residual gases and detects partial pressures between $10^{-11}$ and $10^{-10}$ Torr. Besides the major constituent, hydrogen, traces are found of helium, neon, carbon monoxide, and methane. (auth)

**31780** PERFORMANCE OF A DOUBLE-WALLED UHV CHAMBER. R. A. Metcalfe and F. W. Trabert (Consolidated Vacuum Corp., Rochester, N. Y.). p.1211-17 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

An experimental ultra high vacuum system employing an inner and an outer chamber is described. Its 16 ft$^3$ working volume is somewhat larger than previously reported systems employing this approach. No gaskets are used on flanges on the radiantly heated inner chamber. Pressures of 2 to $3 \times 10^{-10}$ and lower were observed on both exposed and tubulated B–A type ion gages. Studies of pressure vs temperature relationships, outgassing rates, leakage rates, etc. are presented. Measurements made to date indicate the steps required to extend the system's capabilities beyond the $10^{-10}$ Torr range. (auth)

**31781** UHV-CONTROLLED ATMOSPHERE TEST CHAMBER USING MERCURY VAPOR PUMP SETS. Paul J. Bryant and C. M. Gosselin (Midwest Research Inst., Kansas City, Mo.). p.1224-7 of "1961 Transactions of the

Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

An UHV system, capable of producing an indicated pressure of $2 \times 10^{-13}$ Torr or a controlled atmosphere of a known gas at any desired pressure between $10^{-11}$ and $10^{-5}$ Torr, was designed and tested. These results were obtained in a 1.5 liter working chamber by extending standard techniques: a series combination of five mercury vapor pumping stages, one piece glass construction, large conductance cold traps, and a thorough bake-out including four of the five pumping stages. A controlled atmosphere is established by balancing the leak rate of a desired gas (through a diffusor or leak valve) against the pumping speed of the system. Pump speed and ultimate pressure data are reported. (auth)

**31782** MATERIALS EVALUATION UNDER HIGH VACUUM AND OTHER SATELLITE ENVIRONMENTAL CONDITIONS. P. H. Blackmon, F. J. Clauss, G. E. Ledger, and R. E. Mauri (Lockheed Aircraft Corp., Palo Alto, Calif.). p.1244-59 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

A program on the testing of materials for satellite applications is described. Among the more important classes being investigated are lubricants and bearings, paints and other temperature control surfaces, bulk plastics and polymer films, and adhesives. Several lubricating oils have withstood over 4000 hr operating time with small, instrument-type ball bearings when tested at 8000 rev/min and 170 to 180°F bearing housing temperature and $5 \times 10^{-6}$ Torr. Temperature control surfaces are being irradiated with high intensity radiation in the wavelength range 1100 to 4000 Å at pressures on the order of $5 \times 10^{-7}$ Torr. Adhesives and polymers are being subjected to ultraviolet and gamma radiation at elevated temperature. Equipment and data are discussed. (auth)

**31783** APPLICATION OF LIQUID-HELIUM CRYOPUMPING TO LARGE ELECTRIC ROCKET VACUUM FACILITIES. Ronald J. Cybulski, Edward A. Richley, and Thomas A. Keller (National Aeronautics and Space Administration, Cleveland). p.1279-84 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

An experimental evaluation of a toroid-shaped, 6.46 $ft^2$, liquid-helium-cooled cryogenic condensing surface and its application to ion rocket testing in a 314 $ft^3$ ultrahigh vacuum facility is discussed. Data are presented which compare ultimate pressures obtained with a liquid-helium-cooled cryopump with that pressure obtained with a liquid-nitrogen-cooled cryopump operated under varied test conditions. The pumping speeds of these cryopumps are compared with theory. The methods of handling and transporting liquid helium are discussed. The residual gases in the facility are examined with the aid of an omegatron-type mass spectrometer before and during the operation of the cryopumps. (auth)

**31784** COMMERCIAL SEALS AS SEATS IN A BAKEABLE VALVE. J. Ralph Ullman (Univ. of California, Livermore). p.1323-7 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English) (UCRL-6565-T)

A bellows-sealed 3 in. valve is described which is based on the commercially available "Marman Conoseal" tube joint for the gate seat. The application is evaluated and valve operating characteristics are given, for the test valve which gave leakage conductances of $10^{-6}$–$10^{-10}$ atm $cm^3$/sec for air. (auth)

**31785** A CIRCULATING LIQUID-NITROGEN-COOLED BAFFLE FOR ULTRA-HIGH VACUUM SYSTEMS. Alfred R. Taylor (Univ. of California, Livermore). p.1328-31 of "1961 Transactions of the Eighth National Vacuum Symposium Combined with the Second International Congress on Vacuum Science and Technology. Vol. 2." Oxford, Pergamon Press, 1962. (In English)

The development and design of a circulating liquid-nitrogen baffle for bakeable ultra-high vacuum systems is described. Liquid nitrogen is circulated through a spiral tube that is brazed to a copper baffle barrel. This assembly is in turn contained in a stainless steel vacuum jacket. The baffle and circulating system was designed for a complex ultra-high vacuum system requiring eleven diffusion pumps. A 4 in. baffle, unbaked, attained a pressure of $3 \times 10^{-9}$ Torr; a baked (250°C) 6 in. baffle attained a pressure of $3 \times 10^{-10}$ Torr. There is no apparent size limit to this baffle design. (auth)

**31786** IMPROVEMENTS RELATING TO ROTATABLE GAS TIGHT CONNECTIONS PROVIDED WITH A LIQUID RING. (to Société Fives Lille-Cail). French Patent 1,231,160. Sept. 27, 1960.

Containers enclosing reactors are sometimes provided with rotatable covers, the connection being gas tight. Often seals with a liquid ring are used, while a classical sliding seal is provided in a position outside the liquid seal. The gas pressure in the space between these two seals has to be regulated at nearly the same value as that in the container in order to prevent a breakdown of the sealing action. Thus, two sliding seals are provided in series at positions outside the liquid seal. The gas pressure in spaces between two adjacent seals is controlled with respect to the atmospheric pressure and the pressure in the container respectively. (NPO)

**31787** ROTATING FLUID COMPRESSORS. (to United Kingdom Atomic Energy Authority). French Patent 1,235,057. May 23, 1960.

A rotating fluid compressor consisting of a driving shaft passing through a shell containing a fluid of a pressure being essentially equal to the pressure at the other side or a little higher is described. A labyrinth seal is provided between the wall and the driving shaft and is connected in the middle of its length with an exhaust line connecting the seal via filter means with the inlet of the compressor so that any fluid leakage of the seal passes through the exhaust line. Any contamination such as oil or oil vapor coming from the other side of the wall is eliminated by these filter means. A gasket is provided between the compressor rotor and the inner surface of the wall, so that by an axial displacement of the driving shaft this gasket ensures fluid tightness when the compressor is stopped so that the motor casing of the compressor may be removed for maintenance procedures. (NPO)

**31788** IMPROVEMENTS RELATING TO CLOSURE MEANS FOR PRESSURE VESSELS. (to Geartight Unions Ltd.). French Patent 1,247,082. Oct. 17, 1960.

For the closure of openings of reactor pressure vessels, the positioned closure means is locked in its posi-

tion in the access holes by the action of the fluid pressure in the vessel. This means comprises several elements each being adapted for a limited axial movement relative to the others and parallel to the axis of the access hole. The movement of the first elements is effected by an external power during the positioning and removal period. The difference of fluid pressure existing between the two opposite faces of the closure means acts on the second elements. A series of cams is pivotally mounted along the periphery of one of the first elements. These cams abut against a shoulder of an adjacent element moving axially relative to these cams causing an outward movement of the cams which finally engage into an annular groove provided in the access hole wall. The continuation of this axial movement causes the displacement of a locking shoulder for engaging the cams in the groove so that the closure means can not be removed as long as there is a fluid pressure difference between the opposite faces of the closure means. (NPO)

**31789** IMPROVEMENTS RELATING TO FILTER INSTALLATIONS FOR AIR OR GAS CONTAINING RADIOACTIVE PARTICLES IN SUSPENSION. (to Commissariat à l'Énergie Atomique). French Patent 1,247,980. Oct. 31, 1960.

A filter installation for air or gas containing radioactive particles in suspension comprises several filter stages arranged in series, each stage being constituted by a casing enclosing filter elements through which the gas or air stream passes. The filter elements have the shape of bags suspended in a gas-tight way at the edges of their upper open extremities and are easy to extract from the casing by a simple lifting operation. These open extremities communicate with the inlet of the gas stream into the casing, while the filter elements themselves comprise two essentially vertically disposed lateral filter surfaces mutually connected at their lower and lateral edges to form a bag. (NPO)

**31790** THERMAL INSULATION PROCESS FOR PIPINGS, ETC., AND THERMAL INSULATION LININGS OBTAINED BY THIS PROCESS. (to Commissariat à l'Énergie Atomique). French Patent 1,249,964. Nov. 28, 1960.

A composed thermal insulation lining for pipings consisting of a layer of pulverulent thermoplastic resin, then alternating layers of asbestos foils and foils of a thermoplastic resin is described. Adjacent groups of the two alternating layers are separated from each other by thin corrugated strips of aluminum, while a layer of a synthetic resin foam is placed on the pile of the alternating layers, this foam layer being bounded on the outside by a further layer of thermoplastic resin. The thermoplastic resin may be polyethylene, polyurethane, silicone, or other appropriate synthetic resin. (NPO)

## Heat Transfer and Fluid Flow

**31791** (EURAEC-289) DEVELOPMENT PROGRAM ON THE APPLICATION OF STEAM-WATER SPRAY TO REACTOR COOLING. CAN 3—Progress Report No. 1, December 15, 1961–March 31, 1962. (Centro Informazioni Studi Esperienze, Milan). Apr. 5, 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 056-62-1 RDI. 21p. (CISE-R-54)

Initial progress is reported in a program concerned with large scale experiments on heat transfer and hydrodynamics using steam-water mixtures, and in-pile experiments on the behavior of steam-water mixtures under radiation (radioactivity entrainment, radiolysis, corrosion). The facilities used for these experiments are respectively, a loop, modified and expanded, existing at Ansaldo, Genoa, and already exploited under the CAN-1 program for steam-water mixing and separation tests, and a loop, specially designed, for in-pile experiments. Modification work is in progress on the Ansaldo loop. This facility will be equipped with a d-c generating system for electrical heating of the test elements (maximum power 1.16 Mw). The design of the in-pile loop is in progress with the help of preliminary experiments now under way. Orders were placed for all the components of the loop. Completion of loop assembly was expected by July 1962. (J.R.D.)

**31792** (HW-65739) STEAM-WATER CRITICAL FLOW USING THE "SEPARATED FLOW MODEL." W. A. Massena (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 20, 1960. Contract AT(45-1)-1350. 11p.

A comparison of the critical mass velocity for steam-water mixtures as calculated by the homogeneous flow model and by the separated flow model is presented. Experimental data are included to demonstrate the agreement of results with those predicted by the separated flow model. (J.R.D.)

**31793** (HW-73902) EXPERIMENTAL OBSERVATIONS OF UPSTREAM BOILING BURNOUT. J. K. Anderson, E. D. Waters, and J. M. Batch (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 1, 1962. Contract [AT(45-1)-1350]. 16p.

Boiling burnout conditions are usually postulated and observed to occur at the outlet end of uniformly heated test sections. However, during experiments with flow through a 12-ft cylindrical test section, boiling burnout conditions were sometimes observed to begin at various upstream locations. These conditions were observed at mass velocities of $5.0 \times 10^6$ lb/hr-ft$^2$ and higher, but not at lower mass velocities. Local qualities for upstream burnout were 10 to 30 wt % at a pressure of 1500 psig. Similar results were obtained with both vertical and horizontal test section positioning. In some experiments the heat flux was increased beyond the initial detection of boiling burnout (film boiling), allowing the film boiling condition to spread along the test section. It was found that the temperature excursion which was experienced in going from nucleate to film boiling conditions was greater as the film boiling condition moved upstream to lower quality regions. Heat fluxes with upstream burnout were generally higher than those for downstream burnout with comparable enthalpies. Also, the upstream burnout cases resulted in conditions at the test section outlet which were at much higher heat fluxes than those which might have been expected to produce burnout. (auth)

**31794** (NAA-SR-Memo-4965) ANALYSIS OF GR-3,000 KW MODEL EVAPORATOR AND SUPERHEATER TRANSIENTS. D. Fletchall (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Mar. 10, 1960. Contract [AT-11-1-GEN-8]. 79p.

In the HNPF plant, changes in Na flow rate through the steam generators are used to match changes in demand steam flow to the turbine and to maintain a constant steam pressure. In order to adequately specify the control system equipment and to accurately predict its performance, it is necessary to know the transfer function between Na flow changes and steam flow or steam pressure changes. Results concerning the uncontrolled transient response of a GR-3,000 kw model steam generator which is similar to the HNPF generators are presented. The model steam

generator is simulated on an analog computer and the feasibility of predicting transient behavior is evaluated by comparing transient response of the analog simulation with data from the model generator. It was concluded that with exception of steam pressure and the two Na outlet temperatures, the analog simulation adequately predicts the transient response for fast disturbances. For slow disturbances the analog simulation is in better agreement with measured transients after the initial transient errors in the Na outlet temperatures disappear. (J.R.D.)

**31795** (NASA-TN-D-1214) INVESTIGATION OF FORCED-CONVECTION NUCLEATE BOILING OF WATER FOR NOZZLE COOLING AT VERY HIGH HEAT FLUXES. John W. Schaefer and John R. Jack (National Aeronautics and Space Administration. Lewis Research Center, Cleveland). Mar. 1962. 46p.

The nonuniform axial heat-flux distribution typical of a very high temperature flow nozzle was simulated by resistance heating of variable-wall-thickness Inconel tubes. The coolant water flowed through the constant-inside-diameter test sections at flow rates ranging from $0.45 \times 10^4$ to $1.27 \times 10^4$ lb/(sq ft)(sec)(inlet velocities of 73 to 204 ft/sec). Results are presented for nonboiling forced convection, nucleate-boiling forced convection at local heat fluxes up to 11,200 Btu/(sq ft)(sec), burnout, and pressure drop. All results are compared with existing correlations. The solution for the temperature distribution in a resistance-heated variable-wall-thickness tube and the appropriate heat-transfer relations are derived. (auth)

**31796** (NP-12036) ANALYSIS OF RADIATIVE TRANSFER FOR A GASEOUS CORE VORTEX OF SMALL DIMENSIONS. B. W. Wahl (Douglas Aircraft Co., Inc., Santa Monica, Calif.). Oct. 1961. 48p. (SM-38892)

An investigation was made of radiative properties of a hydrogen plasma and of a hydrogen-uranium mixture. Radiative transfer to the environment for a gaseous core of small diameter was also studied. Particle concentrations and resulting absorption coefficients are presented at various locations in the gas body for a special case of a gaseous core vortex. The data were applied to find the radiative flux through the gaseous boundary of such a vortex, and the spectral distribution is shown. (auth)

**31797** (NYO-10448) A DIFFUSION THEORY ANALYSIS OF BOILING BURNOUT IN THE FOG FLOW REGIME. Leonard Topper (New York Operations Office, AEC). Sept. 1962. 10p.

A boundary-value problem, describing an idealized model for the flow of a fog of liquid droplets in their own vapor through a heated tube, is solved. The theoretical solution for a burnout criterion is in good agreement with some experimental burnout results for a fog of water droplets in high pressure steam. (auth)

**31798** (UCRL-10339) DIRECT CONTACT CONDENSATION WITH TWO IMMISCIBLE FLUIDS (thesis). Daryl Lee Lackey (California. Univ., Berkeley. Lawrence Radiation Lab.). June 29, 1962. Contract W-7405-eng-48. 87p.

The theory, design techniques, and relative economics are presented for three basically different direct-contact condensation processes involving fluids whose condensed phases are immiscible. In the specific system developed for the study, Aroclor 1248 (Monsanto Chemical Corporation) and steam were used. The processes investigated include the injection, and the induction of steam into a high-velocity stream of Aroclor in the throat section of a Venturi. The bubbling of steam into a low-velocity stream of Aroclor, using a packed tower to artificially increase the surface of contact was also investigated. The induction, injection, pressure drop, and heat-transfer characteristics of a Venturi in direct-contact condensation service were experimentally investigated, and empirical correlations for the performance of the unit are included. The performance of a direct-injection device was also experimentally determined, and correlations obtained. A discussion is included concerning the theoretical development of relations which are used to predict the performance of packed towers in direct-contact condensation service. (auth)

**31799** (UNC-5025) TWO-PHASE FLOW PATTERNS WITH HEAT ADDITION. Progress Report, April 1, 1962–June 30, 1962. (United Nuclear Corp. Development Div., White Plains, N. Y.). July 15, 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(30-1)-2876. 18p. (EURAEC-418)

Activities in a program to investigate two-phase flow patterns with heat addition from one wall of a rectangular flow passage are reported. Design of the test strip connectors and support was changed to utilize flame-sprayed aluminum oxide as electrical insulation. The loop framework and test section shielding were installed; the mixer is complete except for final assembly. All of the major equipment for the apparatus was received except the water pump, steam pump, pressure vessel, and quartz windows for the test section. Corrosion tests of phenolic-laminated asbestos were unsatisfactory because of contamination of the water by decomposed phenolics. Thermal shock tests of flame-sprayed aluminum oxide were successful. Photographic techniques are being developed using air-water mixtures in the brass model of the test section. Predictions of critical heat fluxes in the dispersed flow regime were made for this specific test section from a theory based on turbulent diffusion of droplets. According to the model, the critical heat flux occurs when the walls are no longer kept wet by the impingement of droplets. A graphical presentation of the predictions is included. (auth)

**31800** A HELIUM COMPRESSOR, SUPPLIED TO RISÖ FOR CIRCULATION OF HELIUM IN HEAT TRANSMISSION EXPERIMENTS FOR THE DRAGON PROJECT. G. Waagepetersen and J. Gribsvad. Ingeniøren, 6: 38-42(June 1962). (In English)

A compressor for circulating pure helium of about 20 $kg/cm^2$ pressure is described. The compressor is running max 54,000 rpm and sealing is achieved using specially balanced sealing rings of Deva metal in conjunction with sealing air adjusted by Foxboro differential pressure cells to a pressure only about 50 mm water-column lower than the helium pressure. (auth)

**31801** FOG COOLANT TECHNOLOGY AND ITS APPLICATION TO NUCLEAR REACTORS. George A. Sofer (United Nuclear Corp., White Plains, N. Y.). Preprint Paper No. 93. New York, Engineers Joint Council, 1962. 30p.

Fog flow is a term applied to two-phase flow under conditions which cause a large part of the liquid phase to be in a dispersed state within the vapor. The present status of fog cooling technology is summarized with emphasis on the following areas: regions of fog flow stability, pressure drop in fog flow, mean coolant density, critical heat flux data, heat transfer coefficients, mixing and separation devices, and corrosion and erosion. A table shows possible application of fog cooling to various types of reactors. A most attractive application of the coolant is forseen for $D_2O$-moderated reactors. (A.G.W.)

**31802** LIQUID METAL HEAT TRANSFER IN NUCLEAR POWER REACTORS. Aaron J. Friedland (Atomic Power Development Associates, Inc., Detroit). Preprint Paper No. 90. New York, Engineers Joint Council, 1962. 26p.

The status of liquid metal heat transfer studies is briefly reviewed. The sodium cooled Enrico Fermi Fast Breeder Reactor is described, with emphasis on the aspects of design and operation relating to heat transfer. (46 references.) (auth)

**31803** ORGANIC HEAT TRANSFER. Thomas T. Shimazaki, Donald A. Huber, and Kenneth L. Adler (Atomics International, Canoga Park, Calif.). Preprint Paper No. 92. New York, Engineers Joint Council, 1962. 27p.

The heat transfer aspects of organic-cooled, nuclear power reactors are discussed. Typical organic reactor coolants are described. Data on convective heat transfer, boiling heat transfer, and critical heat flux of some organic coolants are presented. Convective heat transfer coefficients and, if the volatilities of the various compounds in the coolant are not too different, boiling heat transfer rates are found to be predictable from generalized correlations available in the literature. The critical heat flux of a polyphenyl coolant mixture is found to increase with addition of high boilers. Heat transfer limitations due to pyrolytic and radiolytic decomposition effects are discussed. Thermal, heat transfer, and hydraulic data for an organic-moderated and -cooled power reactor are given. The possibility of improving organic coolant heat transfer by use of additives and other means is indicated. (48 references) (auth)

**31804** HEAT TRANSFER DURING BOILING. V. M. Borishanskii. p.39-46 of "Dostzheniya i Zadachi v Proizvodstve i Primenenii Kholoda v Narodnom Khozyaistve." Moscow, 1960.

Investigations were made of heat transfer, and a theoretical generalization of the experimental results during film and bubble boiling is presented. The experimental studies of heat transfer during film boiling were carried out using ethyl alcohol, isooctane, octane, benzene, and ethyl ether on heatable graphite and steel surfaces at a rate of heat load $q = (250-900)\cdot 10^3$ kcal/m$^2$hr. Two zones were found to exist in the course of the heat-transfer coefficient $\alpha$ as a function of q: the transition zone and that of fixed film boiling. In the transition zone, $\alpha$ decreased with increasing q. In the zone of fixed film boiling, the heat transfer increased with increasing q. Here the pressure effect on $\alpha$ was identical at all values of q. The self-simulating nature of the kinematics of the vapor bubble motion relative to the linear dimension of the heated surface was determined by following the process photographically by means of high-speed motion pictures. A generalization of the experimental results based on the extended concept of the thermodynamic similarity of substances on the saturation line curve was given for the heat transfer during developed bubble boiling. Treatment of experimental data was done in a generalized thermodynamic coordinate system. It was shown that the experimental data lie along a curve with a maximum deviation of $\pm 30\%$. The generalized dependence formulated allows calculation of the heat transfer on the basis of a single experimental $\alpha$ value together with the critical pressure of the substance in question. The complex character of the pressure effect on the intensity of heat transfer and the impossibility of its representation by a power function with a constant exponent is pointed out. (Referativnyy Zhurnal Khemiya, No. 19, 1961)

**31805** HEAT EXCHANGER TUBES HAVING A RUGGED SURFACE. (to A. Huet). French Patent 1,252,033. Dec. 19, 1960.

Heat exchange tubes with patterns of grooves for increasing the heat exchange surface and the heat exchange are described. Preferably the unevennesses or depressions may have the shape of a truncated cone, the dimensions being a tenth of a mm or greater and being chosen depending on the sort and the temperature and pressure conditions of the heat exchange fluid. The unevennesses may also be provided at heat exchanger tubes having circular, flattened, or lenticular cross-sections and may be provided with cooling ribs, so that the rib surfaces also show the unevennesses. (NPO)

## Instrumentation

**31806** (AD-272430) WIDE RANGE TIME TO PULSE HEIGHT CONVERTER. Technical Note No. 9. P. Thieberger (Sweden. Kungliga Tekniska Högskolan, Stockholm and Sweden. Kungliga Vetenskapsakademien. Nobelinstitutet för Fysik, Stockholm). Feb. 10, 1962. Contract AF(052)-118. 16p.

A fast pulse sampling circuit used with the saw-tooth generator of a fast oscilloscope is described. The arrangement is intended for time measurements such as arising in nuclear half-life determinations or time of flight experiments. It is useful for times ranging from about 10 to the −10th power sec to about 100 sec. (auth)

**31807** (AEEW-R-171) A NEW REACTOR PERIOD METER USED FOR FAST PERIOD PROTECTION. E. P. Fowler (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Establishment, Winfrith, Dorset, England). June 1962. 23p.

The requirements for fast period protection on "DIDO type" Reactors are given. It is shown that these can be met by a suitably modified Reactor Period Meter. There is gain both in safety and cost over the existing installation on DIDO. (auth)

**31808** (AERE-R-3723) THE DESIGN AND APPLICATIONS OF A TRANSISTOR BISTABLE CIRCUIT. J. G. Page (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). July 1962. 45p.

A bistable circuit is described which proved to be suitable for many uses in nucleonic instruments. Its applications as a reversible counter and as a logical element used in conjunction with AND-gates (for fast carry operations) at clock frequencies up to 8 Mc/s are discussed. (auth)

**31809** (AERE-R-4110) FACTORS AFFECTING THE VELOCITY RESOLUTION OF GAS ČERENKOV COUNTERS. A. G. Parham (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). July 1962. 19p.

Those criteria which affect the design of a high resolution gas Cherenkov counter, capable of resolving $\pi$ mesons and K mesons up to 5 Gev/c, are considered. The design principles for Cherenkov counters are described. The following factors affecting velocity resolution are discussed: dispersion in the gas, Coulomb scattering, energy loss, finite beam divergence, momentum spread of input particle beam, aberrations of the optical system, and the value of dr/r. (M.C.G.)

**31810** (ANL-6604) STABILIZED RELAXATION OSCILLATOR. Charles Erwin Cohn (Argonne National Lab., Ill.). Aug. 1962. Contract W-31-109-eng-38. 5p.

An unsynchronized thyratron relaxation oscillator circuit was developed, whose rate is stabilized through the

use of a Schmitt discriminator to determine the thyratron firing point. Drift and jitter in the period are less than 0.1% after warmup. (auth)

**31811** (ARF-1192-6) A STUDY OF THE FEASIBILITY OF USING SCINTILLATING FIBERS FOR LOW ENERGY BETA COUNTING. Final Report. C. Preston (Illinois Inst. of Tech., Chicago. Armour Research Foundation). Feb. 23, 1962. Contract AT(11-1)-578. 31p.

The utility of a low energy beta counting system based on bundles of scintillating fibers was investigated. This approach offers the advantages of a minimum of sample preparation, relative insensitivity to sample form and chemistry, and the ability to be used as a flow counter while retaining much of the efficiency and energy proportionality of liquid scintillation counters. Measurements indicate that 0.5 mm diameter fibers are a near optimum choice which yield an efficiency of 30% for $C^{14}$ counting. Usable efficiencies of 18 to 21% were obtained when the solution was heavily colored. Further improvement in efficiency and sensitivity can be obtained by using two photomultiplier tubes viewing the fiber bundle as opposed to the single-ended geometry employed in this preliminary study. Sample volumes of 50cc are achievable with an improved system and it is suggested that additional work be undertaken to fully exploit the technique. The fiber counter can be of vast utility to many research and industrial groups in a diversity of fields. The ease of use should greatly facilitate analysis and measurements made with the aid of the radioisotopes $C^{14}$, $S^{35}$, and tritium. (auth)

**31812** (ASD-TDR-62-420) IRRADIATION OF A TELEMETERING SYSTEM AND RELATED RECONNAISSANCE SENSORS. B. T. Lowrey and J. C. Mitchell (Chance Vought Corp., Dallas). May 1962. Contract AF 33(657)-7229. 144p. (AD-283351)

The work performed in modifying, instrumenting, and irradiating a minimum telemetering system, and in evaluating the possible use of xerographic storage plates and photomultipliers in a nuclear radiation environment is described. A partially hardened 230 Mc telemetering subsystem consisting of ten sensors, two SCO's, mixer amplifier, FM/FM transmitter, and PM/FM transmitter was dynamically irradiated at the 3 Mw Ground Test Reactor (GTR) for 100 continuous hours during September 1961. The average integrated nuclear radiation exposure for the subsystem was $3.0 \times 10^{16}$ $n_f/cm^2$ (nE > 1.0 Mev) and $8.0 \times 10^{10}$ ergs/gm-(C). Failure of the low pass filters in the two SCO's occurred after an exposure of $4.0 \times 10^{14}$ $n_f/cm^2$ (nE > 1.0 Mev), $1.3 \times 10^{9}$ ergs/cm-(C). Transmitter output power of the FM/FM and PM/FM transmitters failed after an exposure of $6.0 \times 10^{15}$ $n_f/cm^2$ (nE > 1.0 Mev), $2.0 \times 10^{10}$ ergs/gm(C) and $3.0 \times 10^{14}$ $n_f/cm^2$ (nE > 1.0), $8.0 \times 10^{8}$ ergs/gm-(C), respectively. There was no gross change in dark resistivity of a photosensitive amorphus selenium (xerographic) detector after exposure in the GTR's 2 7/8 inch square pneumatic tube to $1.1 \times 10^{8}$ $n_f/cm^2$-sec (nE > 1.0 Mev) $2.1 \times 10^{7}$ ergs/gm-hr(C) for ten minutes. Four photomultiplier tubes were dynamically irradiated in General Dynamics' 3000 curie $Co^{60}$ gamma source on October 1, 1961, to investigate the degree of gamma photon induced dark current saturation. Both types of phototubes exhibited stable response to high light stimuli in a nuclear environment of $2.0 \times 10^{7}$ ergs/gm-hr(C). (auth)

**31813** (ASD-TR-61-528) NEW METHOD FOR THE DETERMINATION OF THERMAL CONDUCTIVITIES BETWEEN 1000° AND 3000°C. Michael Hoch and Donald A. Nitti (Cincinnati. Univ.). Aug. 1961. Contract AF 33 (616)-7123. 67p.

The heat conduction equation in a finite cylinder, heated by high frequency induction and losing heat only by radiation, was solved. In the steady state, the cylindrical surface is at a constant temperature, and the flat circular surfaces exhibit a temperature gradient along the radius. This temperature gradient was analytically correlated to the thermal conductivity. The thermal conductivity of Mo was measured at 2100 to 2400°K and that of V at 1600 to 1800°K; for Mo, $k = -0.191T + 81.0$, for V, $k = 0.0320T - 41.4$ BTU/hr-ft-°F. (auth)

**31814** (BNL-6242) SPARK-CHAMBER LABELING OF TRACKS IN A BUBBLE CHAMBER. J. Fischer and G. T. Zorn (Brookhaven National Lab., Upton, N. Y.). [May 1962]. Contract [AT(30-2)-Gen-16]. 15p.

A method for the study of the interaction of high energy particles of particular masses in a bubble chamber when exposed in an unseparated beam was devised and experimentally tested. It is based on the labeling of bubble chamber tracks with the aid of a spark chamber controlled with a particle-selecting counter telescope. By correlating the positions in the spark chamber with those in the bubble chamber, the tracks of the selected particles may be indicated permitting one to study the interaction of these particles in the bubble chamber or to exclude them as an undesired contaminant of the beam. Several particles may be labeled in each bubble-chamber photograph. A preliminary experiment on labeling of 5-Bev/c $K^-$ tracks in the 20-in. BNL $H_2$ bubble chamber is described. The accuracy that was obtained in the determination of track position in the bubble chamber was ~3 to 4 mm in this case; however, it can be reduced to ~1 mm. Methods used in correlating spark position with bubble-chamber track position are presented and means for improving the precision and the efficiency of scanning and analysis are discussed. The technique may be applied in beams at momenta up to ~200 Bev/c, as it is limited only by the selecting counter system. (auth)

**31815** (CEX-59.4(Pt.II)) AERIAL RADIOLOGICAL MONITORING SYSTEM. II. PERFORMANCE, CALIBRATION, AND OPERATIONAL CHECK-OUT OF THE EG&G ARMS-II REVISED SYSTEM. J. E. Hand, R. B. Guillou, and H. M. Borella (Edgerton, Germeshausen and Grier, Inc., Santa Barbara, Calif.). Oct. 1961. Contract [AT(29-1)-1183]. 67p.

The design, installation, and performance of the Edgerton, Germeshausen & Grier, Inc., Aerial Radiological Monitoring System are described. The system is used to perform aerial surveys of ground radioactivity. It supplies both geographical position and radioactivity data in digital form, suitable for use with automatic plotting procedures. Inaccuracies in the geographic positioning data are proportional to the distance flown from a visual ground check point and are, under optimum conditions, a maximum of 750 ft per 30 miles of flight path. Inaccuracies in the maps on which the data are presented are of about the same order of magnitude. The radioactivity units recorded by the system contain a maximum uncertainty of ±9.5 per cent. The performance data satisfy the design specifications, and data compatibility is achieved with the existing U. S. Geological Survey–Oak Ridge National Laboratory system (ARMS-I). The ARMS-II equipment is installed in a Beech Model 50 Twin Bonanza airplane. A three-man flight crew operates the aircraft and instrumentation during survey flights. Operational checkout of the system was performed Nov. 13 and 14, 1960, over portions of Frenchman Flat and Yucca

Flat, Nevada Test Site. It was concluded that nuclear testing contributed to the surface radioactivity in the northern two-thirds of Yucca Flat and a part of Frenchman Flat but that the natural radioactivity of the surficial materials in the southern third of Yucca Flat and much of the Frenchman Flat area accounts for most of the recorded activity. (auth)

**31816** (DP-738) WALL THICKNESS TESTER FOR TUBULAR OXIDE FUEL. T. Richard Herold (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). July 1962. Contract AT(07-2)-1. 11p.

An instrument is described that uses magnetic reluctance to measure the total wall thickness of uranium oxide fuel elements. The tubular elements have an outside diameter of about 2 inches, a Zircaloy outer cladding thickness of 0.030 inch, a $UO_2$ thickness of about 0.250 inch, and a Zircaloy inner cladding thickness of 0.030 inch. After fabrication the elements are tightly swaged on magnetic steel mandrels and the measurement is made before the mandrel is removed. When the total wall thickness was in the range 0.290 inch to 0.320 inch, the measured wall thickness was correct to within 0.001 inch. (auth)

**31817** (DP-761) GAUGE FOR MEASURING WALL THICKNESS OF IRRADIATED TUBULAR ELEMENTS. G. Brooks Cole (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). Aug. 1962. Contract AT(07-2)-1. 7p.

A remotely operable gage was developed to measure accurately the wall thickness of irradiated tubular fuel elements. The gage is mechanical, and utilizes a carefully designed support, small in area, upon which the tube rests and against which the thickness is measured by a dial indicator. (auth)

**31818** (EIR-25) A PARALLEL PLATE TYPE FISSION COUNTER FOR MONITORING NEUTRON BEAMS FROM REACTOR CHANNELS (MODEL EIR F-1). K. Behringer and H. R. von Gunten (Switzerland. Eidgenossisches Institut für Reaktorforschung, Würenlingen). May 1962. 24p.

A parallel plate type fission counter for monitoring and absolute measurement of neutron beams from reactor channels is described. The counter with its easily exchangeable coated electrodes is operated as a gas flow chamber with an argon–methane (10%) mixture at atmospheric pressure. The electron collection time is 0.2 $\mu$ sec at 250 volt H.T. (auth)

**31819** (HW-74333) COOLANT CHEMISTRY INSTRUMENTATION STUDIES FOR PRESSURIZED WATER REACTORS: WET CHEMICAL ANALYSES. T. F. Demmitt (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). July 30, 1962. Contract AT(45-1)-1350. 42p.

A research and development program is in progress to determine the operating characteristics of automatic analytical instruments for coolant quality control work in pressurized water reactor systems. A report concerned solely with the work performed with wet chemical analyzers is presented. The analyzers currently available commercially appear to be capable of measuring the extremely low impurity concentrations present in pressurized water reactor systems. One of the commercially available analyzers was evaluated for specific application in systems of this type. The analyzer proved to be extremely sensitive and accurate for chloride, hydrazine, silica, and phosphate analyses in the low parts per billion concentration range of interest for this application. (auth)

**31820** (HW-SA-2413) IONIZATION CHAMBER AIR SAMPLING SYSTEM FOR TRITIUM. G. A. Little (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 17, 1962. Contract [AT(45-1)-1350]. 10p.

A rapid, inexpensive air sampling system was devised which will detect one MPC ($5 \times 10^{-8}$ $\mu$c/cc) of tritium oxide in air. The system uses a one-liter ionization chamber for a sample collecting–measuring chamber and an ionization chamber pulse reader for sample activity measurement. Accuracy of the system is ±25%. Concentrations of $5 \times 10^{-8}$ $\mu$c/cc of tritium in air were measured, with results available in less than one hour after sample collection. The system has been in routine operation for several months. It has been reliable, and is faster than other available methods for tritium air sampling. The system has also been used for air sampling for other gaseous radioisotopes. (auth)

**31821** (LA-2723) DESIGN CALCULATIONS FOR ROTATING-MIRROR CAMERAS. Eugene A. Igel (Los Alamos Scientific Lab., N. Mex.). May 1962. Contract W-7405-eng-36. 16p.

Relationships are given for the relative positions of the optical axis, images, rotating mirror, and film planes in rotating-mirror smear and frame cameras. (auth)

**31822** (NAA-SR-6542) STEADY-STATE TESTS OF A REACTOR SAFETY DEVICE. T. H. Springer (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Sept. 30, 1962. Contract AT-11-1-GEN-8. 35p.

Two simulated double diaphragm-type safety devices were tested under steady-state conditions in the Livermore Pool Type Reactor (LPTR). The temperatures of the various components in the devices as well as the pressures of the filling gases were investigated at various reactor power levels up to a maximum of 1 Mw. In both cases the temperature of the U-loaded trigger element was found to be well within the acceptable limit of 120°C at the 1-Mw level. In addition, all other component temperatures were within safe limits at this power. Extension of the observed data on gas pressure to a full-scale, operational device indicates that the present design is adequate as far as pressure is concerned, up to probably 700 kw in the LPTR. Above this level, observed pressures would be great enough to rupture the burst diaphragms and thereby cause spontaneous, unnecessary device actuation. The necessity for a neutron "shield" around the stored gas is indicated for operation at higher reactor powers. (auth)

**31823** (ORNL-TM-331) TESTS OF A RESISTANCE-TYPE HIGH-TEMPERATURE SENSOR FOR THE CONTINUOUS MEASUREMENT OF SALT LEVEL IN MOLTEN SALT FUELED REACTORS. Robert F. Hyland (Oak Ridge National Lab., Tenn.). Aug. 21, 1962. Contract [W-7405-eng-26]. 67p.

An accurate, reliable sensor is needed for the continuous measurement of salt level in molten salt fueled reactors at temperatures ranging from 1000 to 1600°F. Two types of all welded level elements which sense a resistance change that is a function of level were designed and tested in fuel #30 (50 mole % NaF, 46 mole % $ZrF_4$, 4 mole % $UF_4$) and in fuel #130 (62 mole % LiF, 37 mole % $BeF_2$, 1 mole % $UF_4$). The Project 7503 fuel #30 tests were inconclusive because of cancellation of the program before the work was completed. In the molten salt power reactor program tests, the short term performance of one type of element in fuel 130 was

satisfactory; however, a long term calibration drift was evident, necessitating frequent recalibration. (auth)

**31824** (PPAD-455 E) MAGNETIC FIELD SPARK CHAMBERS. G. K. O'Neill, F. V. Murphy, K. Wright, and D. Yount (Princeton–Pennsylvania Accelerator, Princeton, N. J.). June 5, 1962. Contract AT(30-1)-2137. 10p.

Work was carried out to develop magnetic field spark chambers of high resolution. Initial tests were made with a 2-gap, variable spacing, variable pressure spark chamber filled successively with Ne, Ar, He, and H. A 128-gap chamber with thin plates and 3 mm spacing, having a volume of 30 × 30 × 60 cm, was built. Each plate consists of two 0.025 mm sheets of Al supported on 1.5 mm thick frames of epoxy fiberglass. The chamber drive system consists of a hard-tube trigger which fires a 3-electrode pressurized-air spark-gap. This gap then drives 8 other identical gaps, each of which has eight output cables. These go to simple ferrite-core cable-adding transformers. (M.C.G.)

**31825** (RADC-TN-61-188) A BEAM TESTER FOR STUDYING THE CHARACTERISTICS OF D-C AND VELOCITY-MODULATED ELECTRON BEAMS. Technical Report No. 9 on LINEAR BEAM MICROWAVE TUBES. A. S. Gilmour, Jr. (Cornell Univ., Ithaca, N. Y. School of Electrical Engineering). May 1, 1961. Contract AF30(602)-1696. 58p. (RESEARCH REPORT-EE-495; AD-272211)

The description and results are presented of d-c measurements on a beam tester designed primarily for determining the characteristics of velocity-modulated electron beams. Some important features of the tester are: a valve between the electron gun and the drift region, which makes it possible to keep the cathode at pressures below $10^{-7}$ mm Hg at all times, including periods when the drift tube is exposed to air and when changes are being made in the beam-scanning mechanism, etc.; an aperture which may be positioned to make current measurements at any point in an electron beam; a double vacuum system that permits aperture adjusting rods to be moved into and out of the drift-tube region without causing appreciable changes in pressure; and an automatic scanning and recording device, which eliminates the necessity for taking point-by-point measurements in the beam. (auth)

**31826** (TID-16654) IMAGE INTENSIFIER DEVELOPMENT. Final Report, June 15, 1961 to December 14, 1961. H. W. Baker, F. H. Barr, and E. H. Eberhardt (ITT Labs. Div. of International Telephone and Telegraph Corp. Components and Instrumentation Lab., Fort Wayne). Jan. 12, 1962. Contract AT(11-1)-1060. 34p.

Additional development effort on a magnetically focused cascaded image intensifier is described. Special emphasis was placed on improving the background and gain characteristics of the tube. Results of this development show that by tube redesign the background brightness was significantly reduced (by two orders of magnitude) and that substantial improvement was also made in S distortion. An improvement in the output photocathode sensitivity was achieved, but difficulty with phosphor screens prevented any appreciable improvement in over-all gain. (auth)

**31827** (TID-16668) A PORTABLE 2½-INCH FREON BUBBLE CHAMBER FOR THE INVESTIGATION OF PARTICLE BEAM PROFILES. F. Bulos, R. E. Lanou, Jr. (Brown Univ., Providence); I. A. Pless, and L. Rosenson (Massachusetts Inst. of Tech., Cambridge). [May 15, 1962]. Contract AT(30-1)-2262. 3p.

The design and operation of a portable freon bubble chamber with a cylindrical sensitive volume 2½ inches in diameter and 2 inches long are described. The bubble chamber was used to investigate the shape of a pion beam in the experiment on pion charge exchange and meson production by pions. The chamber, including the safety box and supports, weighs 100 lb and has over-all dimensions of 18 × 18 × 7 in. (N.W.R.)

**31828** (TID-16721) MEASUREMENT OF THERMAL DIFFUSIVITY IN SMALL SPECIMENS. A. E. Powers (Knolls Atomic Power Lab., Schenectady, N. Y.). [Aug. 20, 1962]. Contract W-31-109-eng-52. 17p.

The cyclic thermal-wave method of measuring thermal diffusivity was used to derive data on thermal capacity of Zircaloy-2. The apparatus initially employed a thermocouple spacing of about ⅓ in. The apparatus was subsequently refined to permit measurements over a gage length of about 0.08 in. using dual-channel recording and a cyclic period of 8 sec. (auth)

**31829** (UCRL-6727-T) ENHANCEMENT OF SIGNAL-TO-NOISE RATIO BY CONTINUOUS AVERAGING. Melvin P. Klein and George W. Barton, Jr. (California. Univ., Livermore. Lawrence Radiation Lab.). June 1, 1962. Contract W-7405-eng-48. 14p.

Spectroscopic investigations require a measurement of power as a function of wavelength or energy of the exciting radiation. For improvement of signal-to-noise ratio, an approach to the problem is to accumulate many rapid scans of the full spectrum so that the signals add coherently whereas the noise adds randomly. The voltage from the output terminals of a spectrometer is converted to pulses, the pulse rate being proportional to the voltage. The channels are opened successively in synchronism with the progress of the magnetic field. Thus each channel corresponds to a finite region of field while the number of counts in each channel is the integral of voltage corresponding to that field. The signal increases directly as the number of scans while the noise increases as the square root of the number. In effect the average response is computed continuously. The great dynamic range, $10^6$ pulses per channel, precludes overloading or saturation effects. Since no long time constants are employed, low-frequency noise is no longer the limiting factor in equipment performance. Spectra are presented which demonstrate that signal-to-noise ratio may be enhanced by orders of magnitude without sacrifice of bandwidth. (auth)

**31830** (UCRL-6835-T) X-RAY DIFFRACTOMETRY ABOVE 2000°C. Deane K. Smith (California. Univ., Livermore. Lawrence Radiation Lab.). Mar. 16, 1962. Contract [W-7405-eng-48]. 16p.

Techniques used to obtain temperatures of 2000 to 2400°C with resistance-type heating elements are discussed. The equipment used in the experiments included a commercial diffractometer furnace. The heater was made of a ribbon of refractory metal or oxide. Other discussion concerns x-ray diffraction studies in air and the development of x-ray furnaces. (J.R.D.)

**31831** (UCRL-6911(Pt.II)) A HELIUM-3 NEUTRON SPECTROMETER WITH EXTENDED ENERGY RANGE: PART II. METHOD OF ENERGY-RANGE EXTENSION (thesis). Wilbur Knight Brown (California. Univ., Livermore. Lawrence Radiation Lab.). May 1962. Contract W-7405-eng-48. 93p.

A method of extending the energy range of the $He^3$ neutron spectrometer is described. The method provides the instrument with the capability of analyzing continuous neutron spectra which include neutrons of energies in excess

of 1 Mev. A counter tube of the "wall-less" design was constructed to minimize wall effect. Krypton at relatively high pressure was introduced along with the $He^3$ to provide shorter ionization tracks. A computer code was formulated and programmed to unfold $He^3$ recoil spectra from recorded pulse-height spectra. The method was tested through observation of the pulse-height spectrum resulting from a monoenergetic source of 3.44-Mev neutrons. Comparison of the spectrum with and without the wall-less feature clearly exhibits the exclusion of wall effect. Treatment of the wall-less spectrum with the computer code demonstrates the ability to remove the $He^3$ recoil spectrum. (auth)

**31832** (UCRL-10251) DIGITIZED MEASURING PROJECTOR FOR THE ANALYSIS OF SPARK-CHAMBER PHOTOGRAPHS. J. C. Hodges, D. Keefe, L. T. Kerth, J. J. Thresher, and W. A. Wenzel (California. Univ., Berkeley. Lawrence Radiation Lab.). May 25, 1962. Contract W-7405-eng-48. 8p.

A measuring projector for use with spark chambers is described which makes the scanners work less painstaking and eliminates part of the transcription errors that a scanner is prone to make. The device presents the scanner with a ruled line which may be adjusted until it coincides with the spark. An x, y coordinate of this line and its direction are then automatically recorded on punched paper tape. Variations of the design and uses of the method are discussed. (J.R.D.)

**31833** (UCRL-10287) PRELIMINARY OPERATING EXPERIENCE WITH HOUGH-POWELL DEVICE PROGRAMS. Howard S. White (California. Univ., Berkeley. Lawrence Radiation Lab.). July 11, 1962. Contract W-7405-eng-48. 20p.

Developmental effort on ways to incorporate the Hough-Powell Device (HPD) into large-capacity bubble chamber data-measurement system is reported. An integrated system of instrumentation and programs known as the Flying Spot Digitizer (FSD), one component of which is the HPD, is described. Preliminary results without the use of the digitizing projector (not yet available) obtained in an analysis of a bubble-chamber photograph are included. (J.R.D.)

**31834** (AEC-tr-5364) A NEUTRON SCINTILLATION COUNTER WITH LOW SENSITIVITY FOR GAMMA-RAYS. V. G. Brovchenko and G. V. Gorlov. Translated from p.297-303 of "Proceedings of the Conference on Nuclear Electronics, held in Belgrade, May 15-20, 1961. Vol. II" (a publication of the International Atomic Energy Agency, Vienna, 1962. (STI/PUB/42(Vol.II(p.297-303)). 10p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 16, as abstract no. 20787.

**31835** (AEC-tr-5366) CADMIUM SULPHIDE CRYSTAL COUNTERS. M. Borisov and M. Marinov. Translated from p.363-77 of "Proceedings of the Conference on Nuclear Electronics, held in Belgrade, May 15-20, 1961. Vol. I" (a publication of the International Atomic Energy Agency, Vienna, 1962. (STI/PUB/42(Vol.I(p.363-77)). 19p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 16, as abstract no. 20742.

**31836** (AEC-tr-5367) GAS SCINTILLATION COUNTER FILLED WITH $He^3$ FOR NEUTRON FLUX SPECTROMETRY. S. A. Baldin and V. V. Matveev. Translated from p. 37-45 of "Proceedings of the Conference on Nuclear Electronics, held in Belgrade, May 15-20, 1961. Vol. I" (a publication of the International Atomic Energy Agency, Vienna, 1962. (STI/PUB/42(Vol.I(p.37-45)). 11p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 16, as abstract no. 20710.

**31837** (AEC-tr-5370) A SLOW-NEUTRON SCINTILLATION COUNTER INSENSITIVE TO GAMMA RADIATION. I. V. Kirpichnikov. Translated from p.139-41 of "Proceedings of the Conference on Nuclear Electronics, held in Belgrade, May 15-20, 1961. Vol. I" (a publication of the International Atomic Energy Agency, Vienna, 1962. (STI/PUB/42(Vol.I(p.139-41)). 6p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 16, as abstract no. 20718.

**31838** (UCRL-Trans-864) QUADRUPOLE MAGNETIC LENSES: THE CERN DEVICE FOR FOCUSING THE BEAM OF $\mu$ MESONS. E. Braunersreuther, V. Chabaud, C. Delorme, and M. Morpurgo (European Organization for Nuclear Research, Geneva). Translated by R. R. Mudge (California. Univ., Berkeley. Lawrence Radiation Lab.) from report CERN-61-12. 58p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 15, abstract no. 24384.

**31839** A METHOD FOR LIQUID SCINTILLATION COUNTING UTILIZING ULTRASONIC EXTRACTION. Janos Schulze and F. A. Long (Cornell Univ., Ithaca, N. Y.). Anal. Biochem., 4: 99-102(Aug. 1962). (In English)

Details are given on a new, rapid method for the extraction and counting of aqueous solutions of isotopically labeled organic molecules. Application of the method to kinetic measurements, such as acid-catalyzed detritiation, is illustrated and discussed. (auth)

**31840** QUANTITATIVE CARBON-14 AND TRITIUM ASSAY OF THIN-LAYER CHROMATOGRAPHY PLATES. Fred Snyder and Nelson Stephens (Oak Ridge Inst. of Nuclear Studies, Tenn.). Anal. Biochem., 4: 128-31(1962). (In English)

A fast and reliable technique for recovering essentially 100% of total carbon-14- and tritium-labeled lipids separated on thin-layer chromatography (TLC) plates is described. Cab-O-Sil, a gelling agent, was used to suspend the TLC adsorbent in a liquid scintillator solution, and for this reason the procedure requires no elution steps. (auth)

**31841** OXYGEN FLASK COMBUSTION IN DETERMINATION OF $C^{14}$ AND $H^3$ IN BIOLOGICAL MATERIALS. Vincent T. Oliverio, Charlene Denham, and Jack D. Davidson (National Cancer Inst., Bethesda, Md.). Anal. Biochem., 4: 188-9(Aug. 1962). (In English)

Modifications are described in a technique for the rapid quantitative measurement of $C^{14}$ and $H^3$ in biological materials by liquid scintillation counting of the products of oxygen flask combustion. Good results are reported in applications of the method in pharmacological studies in animals in which $C^{14}$- and $H^3$-labeled compounds were used. (C.H.)

**31842** A MASS SPECTROMETER FOR ISOTOPE RATIO ANALYSES. A. O. Nier (Univ. of Minnesota, Minneapolis), W. R. Eckelmann, and R. A. Lupton. Anal. Chem., 34: 1358-60(Oct. 1962).

A modification of an isotope ratio mass spectrometer is presented which has performed continuously over extended periods of time with limited downtime (<5%). It is believed that the use of a battery operated emission regulator has reduced the downtime of the instrument to this low level. Carbon isotopic analyses of carbon dioxide gas illustrate the usefulness of this instrument. (auth)

**31843** EVOLUTION OF MULTICHANNEL PULSE HEIGHT ANALYZERS AS DATA HANDLING AND PROCESSING SYSTEMS. U. Pellegrini (Università, Milan). Energia nucleare (Milan), 9: 407-16(July 1962). (In Italian)

Some recent developments concerning new applications and new lines of project in pulse height analyzers are taken into consideration. Particular attention is devoted to their applications in the following cases: a) Statistical distribution and correlation function measurements; b) Activation analysis measurements; c) Data handling in multicounter experiments. As a conclusion, it seems possible to determine two different lines of evolution: the one is to utilize the analyzer with little modifications in several fields of precision measurements; the other is to plan a system with many inputs of high flexibility and short access time, but with a high storage capacity by using ferrite-core memory as a derandomizer and magnetic tape as a central memory. (auth)

**31844** NEUTRON FLUX MEASUREMENTS USING DYSPROSIUM DETECTORS. G. Ben-David and B. Huebschmann (Israel Atomic Energy Commission, Rehovoth, Israel). J. Nuclear Energy, Pts. A & B. Reactor Sci. and Technol., 16: 291-5(June 1962).

A simple method is described which permits measurements of thermal neutron flux using dysprosium foils. The epithermal component is measured using the dysprosium foils and another foil detector having an appreciable resonance cross section, e.g., gold or indium. This method was used in the calibration of the Israel swimming pool-type research reactor at Nahal Sorek. (auth)

**31845** THE USE OF A PHOSPHORUS-POLYTHENE MIXTURE FOR FAST NEUTRON MEASUREMENTS. K. G. Stephens and G. H. Williams (Associated Electrical Industries Ltd., Aldermaston, Berks, Eng.). J. Nuclear Energy, Pts. A & B. Reactor Sci. and Technol., 16: 297-301(June 1962).

A convenient way of measuring relative fast fluxes in a small reactor core using foils of phosphorus-Polythene mixture is described. Determination of the disintegration rate of these foils involves the measurement of the $\beta$-ray self-absorption of the foils as a function of thickness. Accurate disintegration rate measurements after irradiation for 6 hr using $^{7}/_{16}$ in. dia foils enabled fission fluxes of $5 \times 10^5$ n/cm$^2$ sec or more to be measured absolutely to within ± 6 per cent and fluxes as low as $5 \times 10^4$ n/cm$^2$ sec to within ± 20 per cent when the counter background was 80 c/min. By reducing this background and increasing foil size, both of these limits are lowered by about a factor 50. The method compares favorably with methods using the $S^{32}(n,p)P^{32}$ threshold reaction. (auth)

**31846** A MULTICHANNEL PULSE HEIGHT ANALYZER USING PARAMETRON LOGIC. I. Hayashi and M. Ōtsuka (Tokyo Univ.). Japan. J. Appl. Phys., 1: 125-9(Aug. 1962). (In English)

A time conversion type 256-channel pulse height analyzer, which uses a parametron memory circuit, was constructed. The memory cycle was reduced to 100 $\mu$sec by means of a novel logical circuit. An analog-digital converter of the pulse height analyzer can analyze pulses, which come simultaneously from up to eight different counters, and can sort pulses from a counter into up to eight groups, in accordance with coincidence inputs from other counters. (auth)

**31847** STUDY OF CHEMICAL GOLD SENSITIZATION OF NUCLEAR EMULSIONS. Jaroslav Beneš (Tschechoslowakischen Akademie der Wissenschaften, Prague). Phot. Korr., 97: 182-9(1961). (In German)

The possibility of increasing the sensitivity of nuclear emulsions by the use of gold sodium thiocyanate solutions was studied and the following results were obtained: The sensitizing effect of the complex gold sodium thiocyanate is dependent on the ratio of the sodium thiocyanate and gold chloride concentrations in the sensitizing solution. In the beginning, a sensitivity increase was noted and then after passage through a maximum decrease. At high concentration ratios of sodium thiocyanate to gold chloride, a recrystallization of silver halide occurs during the chemical aging in the emulsion. This recrystallization occurs because of the high solubility of some silver halide crystals in NaCNS. The effect of the NaCNS on the sensitivity of the emulsions sensitized by gold sodium thiocyanate was affected by the gelatin used. The curves of the dependence of the sensitivity on the concentration of the complex gold sodium thiocyanates indicate certain maximum attainable limiting values. The sensitizing effect of the gold salts can be increased by the addition of some organic scintillators. A suitable substance for this is, for example, 1-phenyl-2-methyl-3,5-bisdimethyl-aminostyrylpyrazolium iodide. The increase of the sensitizing effect of the gold salts by this compound depends on the aging stage at which the addition is made. For the combined sensitization of nuclear emulsions by gold salts and organic compounds, 2-p-dimethylaminostyryl-benzthiasol can not be used; emulsion layers sensitized in this manner are quite cloudy after development. The experimental dependencies obtained were explained in agreement with the present concepts on the mechanism for the sensitization of emulsions with gold salts. (tr-auth)

**31848** FOCUSING PROPERTIES OF SPIRAL MAGNETIC QUADRUPOLE LENS. Kh. A. Simonyan (Inst. of Physics, Academy of Sciences, Armenian SSR). Pribory i Tekh. Eksp., No. 3, 27-9(May-June 1962). (In Russian)

Charged particle motion in a magnetic field with a spiral gradient is analyzed. A general expression and linear approximation solution are found for the transverse motion equation. It is shown that for a given approximation the spiral quadrupole lens produces the necessary field for stable motion. The trajectory shows that the lens is capable of focusing in both directions, but with a great degree of astigmatism. (tr-auth)

**31849** SEPARATE MEASUREMENTS IN MULTICHANNEL SPECTROMETERS. A. A. Markov. Pribory i Tekh. Eksp., No. 3, 30-5(May-June 1962). (In Russian)

A semi-automatic calculation method is given for separating high-energy Compton components in a complex scintillation spectra and for developing weak-energy photopeaks using a reverse analyzer count and visual indicators. The statistical errors of a difference spectrum are also studied. (tr-auth)

**31850** MECHANICAL NEUTRON CHOPPER SUSPENDED IN MAGNETIC FIELD. S. M. Kalebin and V. V. Vladimirskii (Inst. of Experimental and Theoretical Physics, Academy of Sciences, USSR). Pribory i Tekh. Eksp., No. 3, 36-43(May-June 1962). (In Russian)

A neutron chopper with a 25 kg rotor suspended in a magnetic field is described. The rotor is fixed in space with an accuracy ~0.01 mm and rotates at a set velocity. Control and safety problems are discussed, and chopper parameters are given. (tr-auth)

**31851** RESONANCE 0.3 ev NEUTRON PULSED DETECTOR. I. F. Zhezhurun, I. P. Sadikov, and A. A. Chernyshov (Inst. of Nuclear Physics, Academy of Sciences, USSR). Pribory i Tekh. Eksp., No. 3, 43-7(May-June 1962). (In Russian)

Specifications are given for a pulsed resonance neutron detector operating at 0.3 ev. The detector is constructed of a plutonium ($Pu^{239}$) ionization chamber confined in Sm and Gd filters. (tr-auth)

**31852** FLOATING BUBBLES AND TRACK DISTORTIONS IN BUBBLE CHAMBERS. Yu. A. Aleksandrov, G. S. Voronov, and N. B. Delone (Inst. of Physics, Academy of Sciences, USSR). Pribory i Tekh. Ekspt., No. 3, 50-1 (May-June 1962). (In Russian)

Distortions of particle tracks by floating bubbles are discussed. Improved photographic conditions are suggested, reducing bubble size by factors of 5 to 10 or increasing the speed of bubble growth by higher operation temperature, for reducing the distortion. (R.V.J.)

**31853** EXTERNAL $\gamma$-STANDARD IN DETERMINING THE EFFICIENCY AND BACKGROUND OF LIQUID SCINTILLATION COUNTERS. D. G. Fleishman and V. V. Glazunov (Inst. of Evolution Physiology, Academy of Sciences, USSR). Pribory i Tekh. Ekspt., No. 3, 55-8(May-June 1962). (In Russian)

The efficiency and background of scintillation counters for low-energy beta particles were measured by determining the relation between the $\beta$ spectrum of an isotope and the Campton spectrum of an external $\gamma$ source under fixed geometrical conditions. The method is compared with the ordinary internal standard method. (tr-auth)

**31854** ON THE SHAPE OF ORGANIC SCINTILLATOR COMPTON SPECTRA. Yu. A. Tsirlin, L. N. Shishova, and G. A. Kibal'chich (All-Union Scientific-Research Inst. of Monocrystals, Scintillation, and Special Pure Chemical Materials, USSR). Pribory i Tekh. Ekspt., No. 3, 59-61(May-June 1962). (In Russian)

A nomogram of the shapes of Compton spectra for organic scintillator was developed for determining the scintillator characteristics. A 100-channel spectrometer using 30 to 40 mm scintillators of stilbene, plastic, and naphthalene + antranyl acid was used in the experiment. A typical Compton spectrum from $Cs^{137}$ ($E_\gamma$ = 660 kev) is included. (R.V.J.)

**31855** APPLICATION OF PLASTIC SCINTILLATORS IN $\beta$ SPECTROMETER MEASUREMENTS. N. A. Vartanov, I. M. Rozman, Yu. A. Ryukhin, and Z. D. Chkuasili. Pribory i Tekh. Ekspt., No. 3, 62-4(May-June 1962). (In Russian)

The boundaries of $P^{32}$, $Co^{60}$, $Cs^{137}$, and $Tl^{207}$ $\beta$ spectra and $Ba^{137m}$ conversion lines were determined using a scintillation counter with a polyvinyltoluole phosphor. The results are in good agreement with published data. (R.V.J.)

**31856** ORGANIC CRYSTAL NEUTRON DETECTORS. P. N. V'yugov, V. S. Dementii, S. S. Kalinhenko, and V. V. Tsybul'skii (Inst. of Physics and Tech., Academy of Sciences, Ukrainian SSR). Pribory i Tekh. Ekspt., No. 3, 65-6(May-June 1962). (In Russian)

The design and performance of a neutron detector using standard organic crystals are described. A neutron source (Po + Be), emitting $2.5 \times 10^5$ n/sec, and a 6.17 $\mu$C $Co^{60}$ source were used in the experiment. It is shown that the neutron count rate is constant at 0 to 13 $\mu$C/sec. Reduced $\gamma$ background (and $E_\gamma$) improves the efficiency of neutron recording. (R.V.J.)

**31857** PLASTIC SCINTILLATORS WITH MAXIMUM LUMINESCENCE AT 500 M$\mu$. G. A. Mikhal'chenko, G. F. Nichugovskii, and L. P. Rozhanovskaya (Leningrad Inst. of Tech.). Pribory i Tekh. Ekspt., No. 3, 66-70(May-June 1962). (In Russian)

Descriptions are given of the synthesis, purification, and luminescence of a new plastic phosphors prepared from polystyrene. The phosphor has a maximum luminescence close to the spectral sensitivity of the human eye (507 m$\mu$). The performance of the scintillator for recording ionization radiation is analyzed. (R.V.J.)

**31858** MONITORING $\beta$ ACTIVE GASES IN AIR. A. V. Elpidinskii and S. F. Roslik (Inst. of Physics, Academy of Sciences, USSR). Pribory i Tekh. Ekspt., No. 3, 71-2(May-June 1962). (In Russian)

The radiometer is accurate up to 5% for 18- to 345-kev beta particles. (R.V.J.)

**31859** APPLICATIONS OF FERRITES FOR GENERATION OF STRONG HIGH-VOLTAGE NANOSECOND PULSES. S. I. Andreev, M. P. Vanyukov, and V. A. Serebryakov (State Inst. of Optics, USSR). Pribory i Tekh. Ekspt., No. 3, 89-92(May-June 1962). (In Russian)

High-intensity ($\sim 10^6$ v) nanosecond pulses were produced with a strong spark discharge conductor with ferrite torus. Data are given on the effects of discharge parameters on the amplitude, duration, and frequency of the pulses. (R.V.J.)

**31860** PULSE GENERATOR FOR RECORDING PROBE CHARACTERISTICS. N. I. Leont'ev and V. Ya. Yakovlev (Inst. of Physics and Tech., Academy of Sciences, Georgian SSR). Pribory i Tekh. Ekspt., No. 3, 93-6(May-June 1962). (In Russian)

Descriptions are given of a pulse generator designed for recording probe characteristics in electrodeless pulse charges. The delay between switching in the generator and ignition in the discharge varies smoothly from 50 to 10 $\mu$sec. The current and voltage on the probe scheme are fixed by the generator pulse shape. (tr-auth)

**31861** DURATION OF NUCLEAR QUADRUPOLE RELAXATION. I. A. Safin (Inst. of Physics and Tech., Kazan Branch of the Academy of Sciences, USSR). Pribory i Tekh. Ekspt., No. 3, 98-102(May-June 1962). (In Russian)

Equipment for detecting and measuring nuclear quadrupole relaxation spectra and duration of frequencies from 20 to 150 Mc is described. The results of measurements on $Cu^{63}$ in the $Cu_2O$ powder (transition $\pm \frac{1}{2} \rightarrow \pm \frac{3}{2}$) and $Sb^{121}$ in $SbCl_3$ powder (transition $\pm \frac{1}{2} \rightarrow \pm \frac{3}{2}$ and $\pm \frac{3}{2} \rightarrow \pm \frac{5}{2}$) are included. (tr-auth)

**31862** EQUIPMENT FOR STUDYING PROTON RELAXATION OF LIQUIDS IN WEAK MAGNETIC FIELDS. A. P. Stepanov (Ural Polytechnic Inst., USSR). Pribory i Tekh. Ekspt., No. 3, 102-6(May-June 1962). (In Russian)

The design is given of a device for measuring large (>0.1 sec) duration proton relaxation in low-viscosity liquids by means of spin echo in 0.5 to 5 gauss fields. An increased echo signal is achieved by preliminary polarization of specimens by 50 to 500 gauss fields. The magnitudes of longitudinal relaxation duration, $T_1$, correspond to the intensity of the 50 to 500 gauss field and the transverse relaxation duration, $T_2$, to the 0.5 to 5 gauss field. (tr-auth)

**31863** HIGH-RESOLUTION RESONANCE MASS SPECTROMETER. B. A. Mamyrin and A. A. Frantsuzov (Inst. of Physics and Tech., Academy of Sciences, USSR). Pribory i Tekh. Ekspt., No. 3, 114-19(May-June 1962) (In Russian)

Design and performance of a mass spectrometer capable of orbital time-of-flight separation of ions in a homogeneous magnetic field are described. The resolving power of the dedevice is (25 to 35) $\times 10^3$ at 300 to 500 mm dispersion per 1% mass. (tr-auth)

**31864** DOUBLE-MAGNET MASS SPECTROMETER FOR SMALL ADMIXTURE ANALYSIS. N. I. Ionov and V. I. Karataev (Inst. of Physics and Tech., Academy of

Sciences, USSR). Pribory i Tekh. Ekspt., No. 3, 119-22 (May-June 1962). (In Russian)

The construction and operation of a double-magnet mass spectrometer with a homogeneous magnetic field, capable of quantitative analysis of small admixtures, is described. The quantitative measurements of two peaks for K isotopes, differing by one mass unit at intensity ratios up to $10^7$, are analyzed. (tr-auth)

**31865** DETECTION OF NEUTRAL MOLECULAR BEAMS. V. B. Leonas (Moscow State Univ.). Pribory i Tekh. Ekspt., No. 3, 127-9(May-June 1962). (In Russian)

Descriptions are given of an ionization receiver for recording neutral molecular beams. The device is equipped with a synchronous detector capable of recording below the noise level and of measuring particle velocities by time-of-flight. (tr-auth)

**31866** PERFORMANCE OF A PULSE IONIZATION CHAMBER FILLED WITH TOLUENE–ARGON AND n-HEPTANE–ARGON MIXTURES. V. F. Mikhailov (Inst. of Geology, Academy of Sciences, USSR). Pribory i Tekh. Ekspt., No. 3, 189-90(May-June 1962). (In Russian)

The curves for uranium α particles in chambers filled with various toluene-argon and n-heptane-argon mixtures almost coincided. The optimum toluene and n-heptane vapor concentrations for the highest α-pulse yield are also identical and equal 1-mm mercury per at. of argon. Moreover, the pulse amplitudes in toluene-argon and n-heptane-argon chambers are higher by a factor of 1.47 to 1.49 than those obtained with pure argon. (R.V.J.)

**31867** DEVELOPMENT OF HIGH PULSED MAGNETIC FIELDS IN SMALL AREA. O. Ya. Savchenko. Pribory i Tekh. Ekspt., No. 3, 194-5(May-June 1962). (In Russian)

Production of pulsed magnetic fields of up to 500 k gauss in 1 to 10mm$^3$ areas is described. The minimum pulse duration is ~3μsec. (R.V.J.)

**31868** GAS CONCENTRATION-METER AND DENSITY-METER BY APPLICATION OF RADIATION ABSORPTION. Hiroshi Imamura, Junro Tsujii, and Hiroshi Tominaga (Ube Industries, Ltd. [Japan]). Radioisotopes (Tokyo), 11: 9-15 (Feb. 1962). (In Japanese)

Applications of the measurement of x-ray-absorption for measurement of the concentration of components in a gas mixture, when the atomic number of one component differs adequately from the other, and applications of α-ray absorption for measuring density of gases are reported. Problems of precision and the optimum design of the methods are discussed. (C.H.)

**31869** IONIZATION CHAMBERS FOR INDUSTRIAL USES. E. Petrozzi. Riv. ing., 10: 1209-17(1960). (In Italian)

In the design of ionization chambers, the principal factors to be calculated are the sensitivity, chamber volume required to obtain the desired sensitivity, and the saturation voltage. The calculation of these factors is illustrated together with some supplementary data on insulators, conductors, and polarization. Some typical ionization chambers are described. (J.S.R.)

**31870** ELECTRICAL CHARACTERISTICS OF HALOGENFILLED GEIGER COUNTERS. K. van Duuren. Vide, 16: 235-48(Sept.-Oct. 1961). (In English and French)

The role played by resonance photons in the multiplication process in neon-argon-bromine counters is shown. These photons inherently cause some delay in the building up of the discharge. The difference in delay time may, however, effectively be used with a suitably chosen geometry to transfer the discharge to a region of minimum electrode spacing, in order to effectively reduce the dead time of the counter. The actual delay times for neon-argon-bromine counters can be shorter than those for argon-alcohol counters. Values between $10^{-7}$ and $3 \times 10^{-8}$ sec are found for counters with cathode diameters varying between 0.5 and 4 cm. (auth)

**31871** GAMMA SPECTROMETRY. Gerhard Boucke. Z. Instrumentenk., 12: 3-11(Dec. 1961). (In German)

Gamma spectrometry has become an important auxiliary analytical means in chemistry and physics. Gamma radiation is essentially absorbed by the photoelectric effect, Compton scattering, and pair production. Since at the photoelectric effect, gamma quanta lose all their energy in the absorbing material, this effect generally is used in gamma spectrometry. Because of their very satisfactory resolution power with respect to time and energy and their high efficiency, scintillation counters with NaI(Tl) crystals are preferred to other gamma detectors. The information yielded by the detectors is evaluated by electronic single-channel, gray-wedge, or multichannel analyzers. Single-channel analyzers need a longer testing time, but are less complicated and cheaper than multi-channel analyzers. Supplementary equipment with several detectors and coincidence circuits allows even complex spectra to be easily read. (auth)

**31872** DECREASE OF IONIZATION FLUCTUATIONS OF α-PARTICLES IN ARGON. A. A. Voroev, A. P. Komar, and V. A. Korolev (Ioffe Inst. of Physics and Tech., Leningrad). Zhur. Eksptl'. i Teoret. Fiz., 43: 426-8 (Aug. 1962). (In Russian)

It is shown that an addition of 0.8% of acetylene to argon significantly lowers fluctuations of the pulse amplitudes in an ionization chamber. (auth)

**31873** A COLD NEUTRON MONOCHROMATOR AND SCATTERING APPARATUS. D. Harris, S. J. Cocking, P. A. Egelstaff, and F. J. Webb (Atomic Energy Research Establishment, Harwell, Berks, Eng.). IAEA Preprint No. SM-30/26. 18p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The cold neutrons moderated by a liquid hydrogen source in the reactor pass through a liquid nitrogen-cooled filter, then a single crystal of bismuth, and finally a magnesium-cadmium high-speed curved slot rotor chopper. The wavelength spread of 0.3Å at 4.1Å is determined primarily by the Be-Bi filter, while the time spread (8 μs) is determined by the rotor. The monochromated neutron bursts from this rotor are scattered by a sample and detected in one of two counter arrays. When studying liquid or polycrystalline samples, an array of 6 $BF_3$ counter assemblies (each 2" × 24" in area) are used covering scatter angles from 20 to 90° below the neutron beam. Above the neutron beam is a second array consisting of 3 scintillators (2" diameter) for studying single crystal samples. The output of each counter is fed into a tape recording system which has 500 time channels available for each counter. This apparatus is also used to study neutron scattering from gaseous samples. (auth)

**31874** SCINTILLATION COUNTERS FOR NEUTRON SCATTERING EXPERIMENTS. D. Harris (Atomic Energy Research Establishment, Harwell, Berks, Eng.), L. A. Wraight, and C. Duffil. IAEA Preprint No. SM-30/30. 22p. (In English)

To be published in Proceedings of the IAEA Symposium

on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

LiF or $B_2O_3$ fixed with zinc sulfide and lithium glass scintillation counters are discussed. The ideal composition of each type for neutron scattering experiments and their relative sensitivity to neutrons and $\gamma$ rays are considered. The ZnS type can be used with a $\gamma$-ray pulse shape discriminator and practical experience of its use in a multicounter time-of-flight experiment is described. The lithium glass has higher $\gamma$-background but also higher neutron efficiency. Performance of a scintillator containing 25 wt % $Li_2O$ and 1 mm thick are given. (auth)

**31875** LINEAR DETECTION CHAINS FOR MEASUREMENT OF RADIOACTIVITY: CONSIDERATION OF CHARACTERISTICS AND MAINTENANCE. G. Pelli and A. Ferrero (FIAT, Sezione Energia Nucleare, Turin). p.307-20 of "Atti Ufficiali del Congresso Scientifico, Sezione Elettronica, 22-28 Giugno 1959. VI Rassegna Internazionale Ellettronica e Nucleare." Rome, Palazzo dei Congressi—E.U.R., [1959]. (In Italian)

The characteristics of the linear detection chains for particles are briefly reviewed with respect to the parameters which affect the operation of the preamplifiers and amplifiers. The criteria which must be followed in the design of such a circuit, in the selection of components, and in operation and maintenance in order to obtain the best energy revolutions in spectrometric measurements are given. The results obtained either with a fast ionization counter for $\alpha$ particles or with a scintillation counter for $\gamma$ rays are illustrated. (tr-auth)

**31876** A TRANSISTORIZED PULSER FOR SIMULATION OF RADIATION DETECTORS USEFUL IN CONTROL OF LINEAR ELECTRON CHAINS. G. Pelli, A. Ferrero, and G. Patrone (FIAT, Sezione Energia Nucleare, Turin). p.343-60 of "Atti Ufficiali del Congresso Scientifico, Sezione Elettronica, 22-28 Giugno 1959. VI Rassegna Internazionale Elettronica e Nucleare." Rome, Palazzo dei Congressi—E. U. R., [1959]. (In Italian)

After a summary of the necessary characteristics for a pulse generator used for control in linear detection chains, the criteria for the design and servicing of a very simple transistor circuit, constructed to furnish pulses simulating the signals of proportional counters, are given. Utilization of the pulse generator in the maintanence and testing of a linear detection chain coupled with a multichannel amplitude analyzer is illustrated. (tr-auth)

**31877** USE OF SEMICONDUCTOR DEVICES FOR CONTROL INSTRUMENTATION OF NUCLEAR REACTORS. G. Pelli, G. Caire, L. Parodi, and G. Patrone (FIAT, Sezione Energia Nucleare, Turin). p.363-76 of "Atti Ufficiali del Congresso Scientifico, Sezione Elettronica, 22-28 Giugno 1959. VI Rassegna Internazionale Elettronica e Nucleare." Rome, Palazzo dei Congressi—E. U. R., [1959]. (In Italian)

The singular characteristics of transistors and special semiconductor devices which, in all stages of technical development, are used in electronic circuits are reviewed. Particular emphasis is given to portable apparatus for measurement of radioactivity, devices for nuclear experiments and engineering measurements near a nuclear reactor, and control and guidance systems. (tr-auth)

**31878** PROCEEDINGS OF AN INTERNATIONAL CONFERENCE ON INSTRUMENTATION FOR HIGH-ENERGY PHYSICS, HELD AT THE ERNEST O. LAWRENCE RADIATION LABORATORY, BERKELEY, CALIFORNIA, SEPTEMBER 12, 13, AND 14, 1960. New York, Interscience Publishers, 1961. 338p. $10.00.

Eighty-one papers and one summary of a paper are given. Reports of discussions following some of the papers are included. Papers are grouped into the following sections: beam transport and related topics; detectors and circuits, specialized reports; bubble chambers, specialized reports; performance and capabilities of bubble chambers; developments of general interest in detectors and circuits; techniques involving rare processes, experimental techniques at energies above 20 Bev; reduction of data from bubble chamber film; discharge chambers, beams, and miscellaneous. Seventy-three of the papers are covered by separate abstracts. Seven were abstracted previously for NSA. (A.G.W.)

**31879** HIGH MAGNETIC FIELDS. Harold P. Furth (Univ. of California, Livermore). p.1-8 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Energy, power, and capital investment required for establishing high magnetic fields are compared for iron-core and air-core magnets. Examples are given of applications requiring a high magnetic field and applications depending on characteristics of ironless magnets. A 200-kilogauss pulsed magnet in use at Brookhaven is described. Mechanical strength of coil materials, electrical efficiency of air-core coils, and energy storage systems are discussed. (A.G.W.)

**31880** SOME SPECIFIC USES OF HIGH MAGNETIC FIELDS. Leona Marshall (Brookhaven National Lab., Upton, N. Y.). p.12-13 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

High-field large-volume auxiliary magnets can be used as switches to bring desired particle beams to a given piece of experimental equipment. A 20-Bev charged particle in a field of $10^5$ gauss suffers a deflection of 8.4° in a path length of 1 meter. A coil to produce such a deflection is described. Construction of a strong-focus quadrupole lens with short focal length capable of collecting into a parallel beam particles radiated into a large solid angle is also described. (A.G.W.)

**31881** CRYOGENIC MAGNET COILS FOR HIGH-ENERGY PHYSICS EXPERIMENTATION. Richard F. Post and Clyde E. Taylor (Univ. of California, Livermore). p.14-24 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Calculations are presented which show that, if the assumptions made are valid, capital cost savings of more than a factor of 2 and power cost savings of more than a factor of 10 could be expected if a cryogenic coil were used instead of a conventional coil in producing large-volume high magnetic fields. From available data on magnetoresistance it appears that either Al or Na in ultrapure form could be used for such coils. Na seems to have advantages over Al. Work is in progress on a "full-scale" test of the feasibility of cryogenic coils at Livermore. (A.G.W.)

**31882** GLASS CATHODES IN VACUUM-INSULATED HIGH-VOLTAGE SYSTEMS. Joseph J. Murray (Univ. of California, Berkeley). p.25-33 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Both small-gap low-voltage and large-gap high-voltage experiments were conducted with glass cathodes in vacuum-insulated systems. The glass was heated to lower its resistivity and cause it to behave like a conductor in the stat-

ic realm. Plots of gap length vs. electric field and gap current vs. voltage are shown. An ion exchange process was observed at voltages between 300 and 400 kv, but it was effectively suppressed by introduction of any one of several different gases into the system at pressures from a few tenths of a $\mu$ to a few $\mu$ of Hg. (A.G.W.)

**31883** ELECTROMAGNETIC MASS SEPARATION AT HIGHER ENERGY. Myron L. Good (Univ. of Wisconsin, Madison). p.34-6 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Arguments based on extrapolation of existing d-c separator techniques indicate that, with careful attention to tolerances, K mesons and antiprotons can be separated from pions at energies up to 15 Bev/c. (A.G.W.)

**31884** LOW-NOISE FAST AMPLIFIERS. Michiyuki Uenohara (Bell Telephone Labs., Inc., Murray Hill, N. J.). p.37-44 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Recent activity in the field of low-noise microwave amplifiers is reviewed. The principle of parametric amplifiers is described and typical noise figures are given. Tunnel diodes and coaxial microwave transistors are discussed. (A.G.W.)

**31885** TUNNEL DIODE HIGH-SPEED CIRCUITS. Hanoch Ur (Radio Corp. of America, Camden, N. J.). p.45-53 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Tunnel diode circuitry is discussed with emphasis on the problems, possible solutions, and inherent limitations. The voltage-current relationship and internal capacitance, inductance, and resistance are given. Simple relationships are derived from these parameters which indicate the circuit's impedance level and maximum operating speed. The stability of the device under various biasing conditions is studied and used to explain the various switching modes and the waveforms obtained. A variation of the tunnel diode known as the "tunnel diode rectifier" acts as a directional diode. Two binary counters are described that are capable of an input pulse repetition rate of up to $2 \times 10^7$. The use of the tunnel diode for Class A amplification is discussed. (A.G.W.)

**31886** PERFORMANCE OF A TRANSISTORIZED NANOSECOND COUNTING SYSTEM. Robert M. Sugarman (Brookhaven National Lab., Upton, N. Y.), Adrian C. Melissinos, and J. S. Weaver. p.59-61 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A simple counting system with resolving times of the order of 1 to 2 nsec and a 100-Mc repetition rate, which uses only transistorized components, is described. The system consists of a coincidence circuit, a 100-Mc discriminator and scale-of-2 circuit, a driver, limiters, and fanouts. (A.G.W.)

**31887** TUNNEL DIODE DISCRIMINATOR. Quentin A. Kerns, Arthur E. Bjerke, and Thomas A. Nunamaker (Univ. of California, Berkeley). p.62-3 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A tunnel diode discriminator designed to operate directly from photomultiplier pulses having a 30:1 range in amplitude is described. The discriminator circuit is shown. Slewing characteristics and delay curves as functions of clipping-line lengths are given. (A.G.W.)

**31888** NANOSECOND LIGHT PULSE FOR COINCIDENCE TIMING. Quentin A. Kerns (Univ. of California, Berkeley). p.64-6 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The coincidence timing of an array of photomultiplier detectors has been facilitated by using a light-pulse generation system to simulate a nuclear event. The system comprises a pulse generator, pulse-splitting transformers, cable delays, and individual lamps placed to illuminate each phototube. A corona discharge of about 2 nsec duration is the source of light. It produces a wide optical spectrum and ample light, and has negligible time jitter. (auth)

**31889** A FAST 20-CHANNEL PULSE-HEIGHT ANALYZER EMPLOYING LINE CODING. C. Infante, I. F. Quercia, and C. Solimani (Comitato Nazionale per le Richerche Nucleari, Frascati, Italy). p.67-74 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A block diagram of the pulse-height analyzer, circuit diagrams of each component, and calibration curves for input pulses of 15- to 40-nsec duration are shown. (A.G.W.)

**31890** REVIEW AND EVALUATION OF FAST INTEGRAL DISCRIMINATOR CIRCUITS. C. Infante and U. Pellegrini (Comitato Nazionale per le Ricerche Nucleari, Frascati, Italy). p.75-83 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A class of circuits, commonly called fast integral discriminators, is examined. A number of definitions, pertaining to parameters that determine circuit behavior, is proposed. Diagrams and characteristics of circuits appearing in the literature or developed by the authors are given. Finally the application of tunnel diodes in discriminators is discussed. (auth)

**31891** A COINCIDENCE-ANTICOINCIDENCE GAS ČERENKOV COUNTER. Bruce Cork, Denis Keefe, and William A. Wenzel (Univ. of California, Berkeley). p.84-6 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A counter designed for obtaining pure electronically selected meson (K) beams in the momentum region 1.5 to 5 Bev/c is described. The counter was constructed to accept light produced with $\theta < 6.6°$ in coincidence and to record that with $\theta > 7.4°$ in anticoincidence. Results obtained during a single experiment on $K^-$-nucleon cross section in the Bev region are given. (A.G.W.)

**31892** DISC: A DIFFERENTIAL ISOCHRONOUS SELF-COLLIMATING ČERENKOV COUNTER. L. Gilly, B. Leontic, A. Lundby, R. Meunier, J. P. Stroot, and M. Szeptycka (CERN, Geneva). p.87-8 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Diagrams show the basic design of the counter and an experimental arrangement. Some results obtained with the CERN Proton Synchrotron are given. (A.G.W.)

**31893** GAS ČERENKOV COUNTERS OF THE $K^+$-MESON CHANNEL OF THE SYNCHROPHASOTRON. M. F. Lykhachev, A. L. Lyubimov, V. S. Stavinsky, and Chzan Nai-sen (Joint Inst. for Nuclear Research, Moscow).

p.89-90 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Gas Cherenkov counters used for selection of $K^+$ mesons in particle beams with momenta ranging from 3.0 to 4.75 Bev/c are described. The arrangement contained two similar differential counters, which counted the K mesons, and one threshold counter, which registered the $\pi$ mesons and was connected with the anticoincidence circuit. (A.G.W.)

**31894** A MULTICHANNEL FOCUSING ČERENKOV COUNTER. Robert A. Schluter (Argonne National Lab., Ill.). p.91-2 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Of the information presented at the image surface of a focusing Cherenkov counter, only the signal of a particle of one chosen velocity is usually used. By use of the glass or quartz fiber bundle described, it is proposed to convey the light efficiently from various radii and sectors of the image plane to various corresponding photomultipliers. Several modes are therefore made possible, among which are: (a) response to several chosen velocities simultaneously, (b) simultaneous recording of particles of a different mass, as for monitoring purposes, (c) summing of light at radii off the chosen radius to obtain an anticoincidence signal for delta rays. (auth)

**31895** PRELIMINARY EVALUATION OF A ČERENKOV IMAGE-AMPLIFYING DETECTOR. William Kernan (Argonne National Lab., Ill.), Arthur Roberts, T. Romanowski, Robert A. Schluter, Sydney D. Warshaw, David O. Caldwell, and David A. Hill. p.93-7 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A cone of light produced by a fast particle in a Cherenkov radiator can be focused by a lens to form a circular image on the photocathode of the first stage of an image-intensifier system. The complete image-intensifier system is described, and its optical properties are evaluated. (A.G.W.)

**31896** AN EXPLORATION OF THE POSSIBILITY OF EMPLOYING ULTRASONIC RADIATION TO SENSITIZE A BUBBLE CHAMBER. A. L. Hughes (Washington Univ., St. Louis). p.99 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Water, water saturated with $CO_2$, isopentane, and isopentane with dissolved ethylene were used in a study of the possibilities of using an ultrasonically excited liquid as a bubble chamber. In most cases the ordinary cavitation produced in the liquid by ultrasonic radiation masked any effect that could be caused by the ionizing radiation. Some indication of a positive effect appeared in an experiment in which the liquid was isopentane at atmospheric pressure and at a few degrees below its boiling point. The experiments are being continued. (A.G.W.)

**31897** A 5-LITER RAPID-CYCLING PROPANE OR FREON BUBBLE CHAMBER. H. A. Blumenfeld, T. Bowen, and R. L. McIlwain (Princeton Univ., N. J.). p.100-2 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A small chamber with a useful volume $6 \times 6 \times 7$ in. which can be filled with about 5 liters of propane or freon was constructed to study rapid-cycling operation. A hydraulic expansion system, in which the energy was conserved by storage in the compressed liquid, is described. The system was operated at 5 expansions per sec for as long as 15 min with no impairment of track visibility and no apparent obstacle to running longer. The system is believed to have possibilities for operation at 20 expansions per sec. (A.G.W.)

**31898** DESIGN OF A 30-LITER RAPID-CYCLING HYDROGEN BUBBLE CHAMBER WITH COUNTER-CONTROLLED PHOTOGRAPHY. H. A. Blumenfeld, T. Bowen, R. L. McIlwain, M. Scheibner, L. Seidlitz, and C. R. Sun (Princeton Univ., N. J.). p.103-5 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A rapid-cycling bubble chamber is described which is to be surrounded by counters of various types, both for counter control of photography and to aid in more complete specification of each event by giving auxiliary information. The chamber is to contain 30 liters of liquid hydrogen or deuterium and a piston-type expander will be used. The approximate cost of obtaining 100 $\Lambda^\circ$ $\beta$-decay events in a 900-Mev beam with the chamber described at the Princeton-Penn Accelerator is compared with the cost of the same data obtained with a larger chamber operating at a conventional proton synchrotron. (A.G.W.)

**31899** A PULSED-RESONANT-SYSTEM BUBBLE CHAMBER. J. H. Mullins, E. D. Alyea, Jr., and John M. Teem (California Inst. of Tech., Pasadena). p.106-9 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The expansion system of a freon ($CF_3Br$) bubble chamber, 10.5-in. in diameter by 6.5 in. deep, now operative at the California Institute of Technology Synchrotron Laboratory, utilizes the natural resonance of the system as a whole to achieve rapid expansion and recompression with small required energy. The sensitive fluid is contained in a hydrostatically supported thin-walled chamber with movable windows. Special fast valves of very large port area operating upon the hydrostatic support fluid allow the chamber pressure to oscillate through a single cycle with a natural period of about 14 milliseconds. The fast cycle, along with the large expansion area furnished by the movable windows, results in comparatively uniform expanded conditions with very small heating of the chamber fluid from irreversible processes. Preliminary operating results are presented. (auth)

**31900** XENON BUBBLE CHAMBER. John L. Brown (Univ. of California, Berkeley). p.110-12 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Engineering features of a moderate-size xenon bubble chamber are described. Properties of liquid xenon and operating experiences are discussed. It is concluded that the main advantages of a xenon chamber are high probability for nuclear interactions, high stopping power, and high probability (~70%) for conversion of $\gamma$ rays. The main disadvantages are lack of information concerning basic production reactions and lack of accurate momentum measurements on nonstopping tracks. (A.G.W.)

**31901** IDENTIFICATION OF PARTICLES IN XENON BUBBLE CHAMBER WITHOUT MAGNETIC FIELD. A. P. Karatsuba, E. I. Maltsev, T. Nagy, and J. Nagy (Joint Inst. for Nuclear Research, Moscow). p.113-16 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Methods of identification of charged particles using multiple scattering-residual range and multiple scattering-ionization are described. A working formula, based on the variable-cell-length method, is given for the calculation of masses. The experimental constants, $b = t^{5}/R^{4}$, are introduced. The subtraction of noise is discussed; the mass distributions for $\pi^{+}$ mesons, $K^{+}$ mesons, and protons are given. The theoretical and experimental distributions of the second differences for protons are obtained, taking noise into consideration. There is a possibility for the indication of the particle nature. (auth)

**31902** PERFORMANCE OF THE BROOKHAVEN NATIONAL LABORATORY 20-INCH HYDROGEN BUBBLE CHAMBER. Robert I. Louttit (Brookhaven National Lab., Upton, N. Y.). p.117-20 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961. (BNL-5069)

The BNL 20-in. $H_2$ bubble chamber is described. Results from regular operation and one engineering run are discussed. (A.G.W.)

**31903** REDUCTION OF OPTICAL DISTORTION IN GAS-EXPANSION BUBBLE CHAMBERS. Harley C. Hitchcock and Robert D. Watt (Univ. of California, Berkeley). p.121-2 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A system for reduction of optical distortion due to temperature inhomogeneity in gas-expansion bubble chambers is described. Injection of liquid $H_2$ at ~26°K into the expansion interface region reduces irreversible vaporization-recondensation losses by 75%. Consequently thermal gradients in the chamber and total thermal inhomogeneity of the system are reduced. Available sensitive volume of the chamber is increased 25% by reduction of turbulence in the chamber bottom. Attainable pulse rate is increased 50% by unloading of the chamber heat exchangers. (A.G.W.)

**31904** BUBBLE CHAMBER HODOSCOPE. John A. Kadyk (Univ. of California, Berkeley). p.123-4 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A simple 4-by-4 hodoscope array was tested during a Xe bubble chamber exposure to an 805-Mev/c $K^{+}$ beam at the Bevatron. During a part of the experiment when the beam was tuned for $\pi^{+}$, 95% of the tracks seen in the chamber were located correctly by the hodoscope. Possible improvements in the system are discussed. (A.G.W.)

**31905** THE PRINCIPLES OF THE DESIGN OF THE CERN PROPANE BUBBLE CHAMBER. C. A. Ramm and L. Resegotti (CERN, Geneva). p.127-32 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The CERN propane bubble chamber being assembled will have a working volume of 500 liters in a magnetic field of ~24 kilogauss. The chamber body is made of circular stainless steel forgings, mirror finished internally. The useful diameter of the sensitive region is 115 cm. The expansion system will work with $N_2$ from a compressor of 400 hp. The bubbles will be illuminated by 8 symmetrically disposed flash lamps located axially near the inner surface of the chamber. (A.G.W.)

**31906** CAMBRIDGE GROUP HEAVY-LIQUID BUBBLE CHAMBER. Lawrence Rosenson (Massachusetts Inst. of Tech., Cambridge). p.133-4 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A heavy-liquid bubble chamber 15 in. in diameter by 14 in. deep and an associated 20-kilogauss d-c electromagnet were constructed and operated by the Cambridge Bubble Chamber group. The main new features described are the successful operation of the system with a ternary mixture of methyl iodide, propane, and ethane and the inclusion in the bubble chamber system of pressurized safety boxes to support the chamber windows. (A.G.W.)

**31907** THE 1-METER PROPANE BUBBLE CHAMBER IN A MAGNETIC FIELD. Yu. A. Budagov, V. P. Dzhelepov, N. I. Dyakov, V. B. Flyalin, and T. Shatet (Joint Inst. for Nuclear Research, Dubna, U.S.S.R.). p.135-9 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A large bubble chamber placed within the central field of an electromagnet producing a constant magnetic field of 15000 oersteds is intended for research with high-energy particles at the 10-Bev synchrophasotron. The chamber, the photography system, the expansion system, and the principal nuclear characteristics of the chamber are described. (A.G.W.)

**31908** A 300-LITER HEAVY-LIQUID BUBBLE CHAMBER. A. Rousset (Ecole Polytechnique, Paris). p.140-1 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A 300-liter bubble chamber was built at the Physics Laboratory of the Ecole Polytechnique. The chamber operates in a magnetic field of 20,000 gauss with propane and mixtures of freon and propane. With a mixture of 50% propane, 50% freon (by volume), momentum measurements can be performed with an accuracy of the order of 10%. At the same time, information arising from the use of a dense high-Z medium, making use of stopping power and $\gamma$-ray detection, can be obtained. (auth)

**31909** EXPERIENCE WITH A LARGE HYDROGEN BUBBLE CHAMBER. Luis W. Alvarez (Univ. of California, Berkeley). p.145-9 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Main features of the design of the Lawrence Radiation Laboratory 72-in. bubble chamber are summarized, and its operating history is reviewed. Cost of operation, some troubles encountered, and some modifications made are discussed. Reasons why it appears to have been a good idea to build the 72-in. chamber are given. (A.G.W.)

**31910** COMPARISON AMONG TYPES OF BUBBLE CHAMBERS. Donald A. Glaser (Univ. of California, Berkeley). p.150-3 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Characteristics of some types of bubble chambers and the liquids used in them are compared. Experiments done in each type of chamber are reviewed. Possible future uses of bubble chambers are discussed. (A.G.W.)

**31911** APPLICATION OF THE HELIUM THERMOCYCLE FOR A LIQUID HYDROGEN BUBBLE CHAMBER. V. M. Dobrov (Inst. of Theoretical and Experimental Physics, Moscow). p.154-7 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A round table discussion included brief reports on the following subjects: a refrigeration system utilizing an ex-

pansion engine in a gaseous He cycle being developed for the Soviet $H_2$ bubble chamber; status of an 80-in. chamber to be built at BNL; design features of a 25-in. chamber to be built at Lawrence Radiation Lab; a study of the feasibility of very large bubble chambers (2 to 5 m). (A.G.W.)

**31912** GAP-LENGTH MEASUREMENT OF BUBBLE TRACKS. Charles Peyrou (CERN, Geneva). p.157-62 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A round table discussion of methods of identifying tracks in bubble chambers included a report on a method of determining bubble density by measurement of mean gap length. The importance of bubble counting and the areas in which it could be useful were discussed. The possibility of using $\delta$ rays in track identification was considered. (A.G.W.)

**31913** ČERENKOV COUNTERS. G. von Dardel (CERN, Geneva). p.166-71 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Principles and properties of Cherenkov counters and their main components (radiators, optical systems, diaphragms and light collectors, and photomultipliers) are discussed. An example of the performance that can be attained with velocity-selective gas Cherenkov counters in high-energy physics is given. It is concluded that the gas Cherenkov counter is an adequate solution to the problem of identifying pions and heavier particles up to the highest energies available with present-day accelerators, but its usefulness is limited by the requirement for a very well collimated beam. (A.G.W.)

**31914** A VELOCITY SELECTIVE GAS ČERENKOV COUNTER. R. Mermod, K. Winter, G. Weber, and G. von Dardel (CERN, Geneva). p.172-3 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The design and resolution of a high-pressure ethylene-filled Cherenkov counter built and used at the 25-Bev proton synchrotron at CERN are described. (A.G.W.)

**31915** SPARK CHAMBERS. A. I. Alikhanian and M. S. Kozodaev (Inst. of Theoretical and Experimental Physics, Moscow). p. 174-6 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Research conducted the last year and a half in USSR Laboratories on the possibility of using a parallel-plate pulsed spark chamber in devices for the determination of the trajectory of high-energy ionizing particles in cosmic rays and accelerators is reviewed. Most of the work was devoted to the building of chambers in which pulsed spark counters were used for the formation of a system of light spots in places where the particle passes through the spark gaps, spaced at some distance from each other. Attempts were also made to create discharge gaps in which breakdown would occur along the particle trajectory. (A.G.W.)

**31916** APPLICATION OF SOLID-STATE DEVICES FOR HIGH-ENERGY PARTICLE DETECTION. Luke C. L. Yuan (Brookhaven National Lab., Upton, N. Y.). p.177-81 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Preliminary results from the use of solid-state devices for detection of high-energy particles in the minimum-ionizing region are surveyed. Some basic characteristics of solid-state detectors are discussed, and some experimental arrangements are shown. Some possible uses of these detectors in high-energy nuclear physics are suggested. (A.G.W.)

**31917** HANDLING OF COUNTER DATA. Clyde Wiegand (Univ. of California, Berkeley). p.182-4 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A system is outlined for recording data from an array of about 100 counter elements on a magnetic tape. An indicator lamp panel, which permits visual sampling of the data being stored, is described. As an illustration of the method, the pion-pion interaction is considered. Data analysis using IBM 704 and 709 computers is discussed. (A.G.W.)

**31918** THE USE OF A SODIUM IODIDE LUMINESCENT CHAMBER TO STUDY ELASTIC AND INELASTIC SCATTERING OF PIONS IN HYDROGEN. Martin L. Perl, Lawrence W. Jones, and Kwan Lai (Univ. of Michigan, Ann Arbor). p.186-91 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The nature of a homogeneous luminescent chamber system and experimental techniques employed are described. Experimental setups used for studying "large-angle" elastic scattering of 1.5 Bev/c negative pions on $H_2$ and pion production from pions on protons are discussed. (A.G.W.)

**31919** MEASUREMENT OF PARTICLE VELOCITY WITH A FILAMENTARY CHAMBER-IMAGE INTENSIFIER SYSTEM. K. Lande, A. K. Mann, K. Reibel, and D. H. White (Univ. of Pennsylvania, Philadelphia). p.192-4 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The method discussed for measuring particle velocities in filamentary chambers is based on track-image rotation produced when a rapidly changing electric field is applied to transverse deflection plates inside the first image intensifier. (A.G.W.)

**31920** SOME THEORETICAL IMPLICATIONS OF HIGH-ENERGY NEUTRINO EXPERIMENTS. C. N. Yang (Inst. for Advanced Study, Princeton, N. J.). p.195-6 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Cross sections of the processes $\nu + n \rightarrow p + e^-$ and $\bar{\nu} + p \rightarrow n + e^+$ are calculated. Things to be learned from such processes are discussed. The possibility of experimentally demonstrating the existence of the intermediate boson is considered. (A.G.W.)

**31921** REMARKS ON HIGH-ENERGY NEUTRINO INTERACTIONS. D. Blokhintsev (Joint Inst. for Nuclear Research, Dubna, USSR). p.197 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The weak interaction (e.g., Compton effect) competes with the electrodynamic process (e.g., generation of $\mu$ meson) only for extremely high-energy particles approximating $10^{11}$ ev. When the weak interaction occurs in an intermediate state, all momenta of the interacting particles contribute to the amplitude, but a cutoff of the momenta of the particles must be assumed for the calculations to agree with experimental information. Possible rates of high-energy neutrino events are discussed. (A.G.W.)

**31922** A NEUTRINO FACILITY FOR THE ZGS. Frederick A. Reines (Case Inst. of Tech., Cleveland).

p.198-200 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Problems associated with the design of a facility for the study of neutrino interactions at the zero-gradient synchrotron are considered. A diagram of the facility is shown. Expected pion and neutrino production is calculated. Experimental space, detector sizes, and shielding needed are discussed. (A.G.W.)

**31923** A NEUTRINO DETECTOR FOR USE AT THE BROOKHAVEN AGS. Leon Lederman, Melvin Schwartz, and Jean-Marc Gaillard (Columbia Univ., Irvington, N. Y.). p.201-2 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The first detector to be tried will be the 30-in. Freon chamber. For follow-up experiments (if they are needed) a 10-ton spark chamber is being considered. The module is a 1-ton box consisting of 6 gaps separating 7 Fe plates each 2 × 6 ft and 1 cm thick. Problems of optics, electrical pulsing, triggering, cosmic rays, and cost are considered. It is concluded that the whole thing seems practical. (A.G.W.)

**31924** THE POSSIBILITY OF THE DETECTION OF NEUTRINO INTERACTIONS IN THE CERN HEAVY-LIQUID BUBBLE CHAMBER. C. A. Ramm (CERN, Geneva). p.203 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

With a chamber-to-target distance of about 70 m, a neutrino event rate of about one per $10^5$ pictures for normal beam intensity in the CERN proton synchrotron and a total neutrino-event cross section of about $10^{-38}$ $cm^2$ have been predicted. Experimental layouts and background events as a function of shielding arrangements are being studied. (A.G.W.)

**31925** THE CATHOLIC UNIVERSITY NEUTRINO-DETECTION SYSTEM. Clyde L. Cowan (Catholic Univ. of America, Washington, D. C.). p.204-6 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Construction of a laboratory model of a large-volume liquid scintillation system to be used for neutrino detection is nearing completion. Lucite-type plastics are used throughout in construction of the detector, and all supporting structures are built of either plastics or wood. The scintillator uses decalin as a solvent with about 1 g of terphenyl and 2 g of α-naphthylphenyl-oxazole per liter of solvent. The detector geometry is described. The status of performance tests, planned experiments, and future development of the system is discussed. (A.G.W.)

**31926** HIGH-INTENSITY NEUTRINO BEAMS. S. Courtenay Wright (Univ. of Chicago). p.207-8 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

It is shown that with the Argonne zero-gradient synchrotron and a novel focusing system a beam of the order of $10^{11}$ neutrinos with energies of more than 1 Bev can be made to pass through a large detector on each machine pulse. Specifications for the ideal magnetic lens for focusing the beam are listed. A lens that meets all the specifications is a linear ion stream, coaxial with the proton beam, and one whose cross section increases along the direction of the particles. The lens action is analyzed, and its feasibility is discussed. (A.G.W.)

**31927** POSSIBILITY OF HIGH-ENERGY NEUTRINO MEASUREMENTS WITH COSMIC RAYS. Kenneth Greisen (Cornell Univ., Ithaca, N. Y.). p.209-11 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Reasons for attempting to detect high-energy cosmic-ray neutrinos are given. Estimates are made of the neutrino energy flux from the following sources: atmospheric pion decay, atmospheric muon decay, interactions in the gas of the galactic disk, interactions in the halo of the galaxy, intergalactic space, supernovae. These estimages indicate that, unless the cross section is larger than that given by Fermi theory, the most interesting phenomena will yield only on the order of one count a year in the unit detector. It is also apparent that the experiment must be set up far underground in order to reduce background events. (A.G.W.)

**31928** FEATURES OF THE CERN PROTON SYNCHROTRON OF INTEREST TO EXPERIMENTERS. M. G. N. Hine (CERN, Geneva). p.214-22 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The general layout of the CERN proton synchrotron is shown. Features discussed include the following: magnet cycles, the internal proton beam, basic principles of internal targets, practical operation of two classes of internal target systems (short-burst systems for track chambers and long-burst systems for counter experiments), secondary beams, shielding, and beam ejection. Possible future developments are considered. (A.G.W.)

**31929** CAPABILITIES AND LIMITATIONS OF PRESENT DATA-REDUCTION SYSTEMS. Hugh Bradner (Univ. of California, Berkeley). p.225-8 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Steps required in present large-volume systems for analysis of bubble chamber data and the average time required for each step are as follows: scanning, 1 min per triad; sketching (including maintaining a master list), 5 min per event; measuring, 10 min per event; computing, ½ min per event; examination of computer output, 30 min per event studied. The number and sources of errors made in present systems and possible improvements in the systems are discussed. It is concluded that analysis of $10^5$ events per year seems to be possible by pushing the system. (A.G.W.)

**31930** SOME RECENT DEVELOPMENTS IN DATA REDUCTION. A. M. Thorndike (Brookhaven National Lab., Upton, N. Y.). p.229-32 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Recent developments in bubble chamber data reduction include a new commercial measuring projector manufactured by Hermes Electronics Company. Several approaches to the problem of obtaining information on measurement errors are suggested. A method of estimating bubble density from gap-length measurements is reported. Experimental investigations of the possibility of electronic scanning of bubble chamber pictures are discussed. (A.G.W.)

**31931** RECENT DEVELOPMENTS IN EUROPE IN BUBBLE CHAMBER DATA REDUCTION. Y. Goldschmidt-Clermont (CERN, Geneva). p.233-8 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A recent survey carried out in 13 European countries showed that by the end of 1960, 34 laboratories would be using a total of 57 type-A projectors and 31 digitized projectors of types B and C. The number of digitized projectors will almost double in 1961, when the commercially made instruments will become available. Almost all laboratories make some use of digital computing. Methods of computation are gradually improving. As the number of measured events increases, the sorting out of the accumulated data is also progressively shifted to the computer. This will become more readily feasible as larger computers with magnetic type equipment are becoming more numerous. Several new ideas are reviewed: the use of a simplified digitized projector, and of preliminary computer operations, to improve the selection operations performed during the initial scanning; a digitized stereoscopic projector, using polarized light to give to the observer the feeling of depth, in order to record directly the spatial coordinates of individual bubbles; a development of the digitized protractor (Baby IEP), which will enable the observer to adjust a circle of variable curvature to the image of the track, and to digitize the track direction and radius of curvature; a further development of the same method, in which the adjustable circle is generated on a cathode-ray tube, and the superposition of the circle on the track is detected and displayed electronically. (auth)

**31932** AUTOMATIC MEASURING DEVICE FOR BUBBLE CHAMBER PHOTOGRAPHS. G. K. Bysheva, V. S. Kaftanov, L. L. Lichtenbaum, V. A. Milekhin, B. A. Moiseev, S. Ya. Nikitin, and O. P. Fedotov (Inst. of Theoretical and Experimental Physics, Moscow). p.239-41 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

An automatic device for measuring large series of bubble chamber photographs has been designed. It employs the method of approximate spectroscopy. The measurements of the coordinates of a number of points along the tracks and of the fiducial marks are performed in an orthogonal coordinate system on at least two out of four stereoscopic views. The information obtained is punched in digitized form on standard perforated cards or recorded on paper tape, depending on the computer used for further data reduction. The time needed for collecting the data for a 5-prong event is about 7 to 8 fmin. (A.G.W.)

**31933** THE SPIRAL READER MEASURING PROJECTOR AND ASSOCIATED FILTER PROGRAM. Bruce H. McCormick and Daphne Innes (Univ. of California, Berkeley). p.246-8 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The spiral reader is a high-speed photographic film measuring projector for making precision measurements of bubble chamber nuclear events. The projector equipment is in three sections: (1) a digitized projection microscope used to project the desired nuclear interaction vertex image on a rotating scanning disk, (2) a rotating scanning assembly that digitally encodes azimuths and radii of points along the track images, and (3) a buffer storage system for transferring these measurements to an output magnetic tape suitable for subsequent processing by a general-purpose digital computer. The spiral reader suffers several limitations. The length of short tracks can be determined only coarsely, and tracks with large curvature produce pulses with poor background-to-track ratios on the outer slits. A new spiral reader is being designed which will probably measure 200,000 interactions each year. (A.G.W.)

**31934** AUTOMATIC SCANNING AND MEASURING OF BUBBLE CHAMBER NEGATIVES. Antonio Graselli (Princeton Univ., N. J.), Bruce H. McCormick, James N. Snyder, and Samuel J. Penney. p.249-55 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A completely automatic system from scanning to computing is discussed, in which the film reel coming from the film-processing unit would be entered into a film transport much like a tape transport and examined under control of a fully digital system without human intervention. Preliminary simulation programs indicate the feasibility of the system. The time scale for the development of such a system might be five years. Subsystems with partial human intervention could be realized along the way. (A.G.W.)

**31935** EQUIPMENT FOR FAST ANALYSIS. Jerome A. Russell (Univ. of California, Berkeley). p.256-7 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Equipment and procedures in use at Lawrence Radiation Lab. for processing bubble chamber film are reviewed. A system is being developed to eliminate manual transmission of data from sketch cards to the measuring projector measurement-data tape. A track-unscrambling computer program (PREPANG), the Spiral Reader measuring projector and the associated FILTER program, and a mechanical line scanner are discussed briefly. (A.G.W.)

**31936** COMPUTER PROGRAMS AND USES. Arthur H. Rosenfeld (Univ. of California, Berkeley). p.258-62 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Two large programs for analyzing bubble chamber data at Lawrence Radiation Lab. are described briefly and compared. The PANG-KICK progrm has handled 1000-event experiments; the FOG-CLOUDY-FAIR program is designed to handle experiments comprising 10,000 to 100,000 events. The cost of processing a 1000-event experiment by a small physics group is estimated. Typical experiences with program rejects and failures and the time required to understand and correct them are discussed. (A.G.W.)

**31937** SPATIAL RECONSTRUCTION OF PARTICLE TRACKS IN BUBBLE CHAMBERS. Frank T. Solmitz (Univ. of California, Berkeley). p.263-5 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The problem of spatial reconstruction of particle tracks is broken down into stages. As one phase in the breakdown the orbit of a single charged track in the bubble chamber is considered and the parameters of this single track are determined from the film measurement. Three methods of doing this (called by the author the Berkeley method, the "ultimate" method, and the CERN compromise) are described and their advantages and disadvantages are discussed. (A.G.W.)

**31938** THE MICROWAVE DISCHARGE CHAMBER — A NEW TYPE OF PARTICLE DETECTOR. Shuji Fukui, Satio Hayakawa, Takashige Tsukishima, and Hideo Nukushina (Nagoya Univ., Japan). p.267-9 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

This device is similar to gaseous discharge chambers

used previously, but it is operated by a triggered pulsed microwave field rather than a d-c pulse. A preliminary test of the detector produced cosmic-ray tracks of the expected brightness and width. Possible changes to suppress background spots and reduce recovery time are suggested. (A.G.W.)

**31939** THE APPEARANCE OF A DISCHARGE IN A FLAT CONTROLLED COUNTER ALONG A PARTICLE TRACK. A. A. Tyapkin (Joint Inst. for Nuclear Research, Dubna, USSR). p.270 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The necessary conditions for the appearance of a discharge along the ionizing particle track in gas discharge chambers in those cases in which the angle between direction of track movement and the direction of the electric field in the counter is less than 30° were investigated. It was found that the most favorable conditions for appearance of the discharge were at 0.5% concentration of Ar in Ne. The discharge was explained on the basis of formation of metastable Ne atoms. (A.G.W.)

**31940** THIN-FOIL DISCHARGE CHAMBERS. Donald I. Meyer and K. M. Terwilliger (Univ. of Michigan, Ann Arbor). p.276 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

Several discharge chambers were constructed with thin foils as plates. Sparking at the foil edges was eliminated by bringing the foils out through the chamber walls. Operating conditions were similar to those found by others. Some experiments using a 3000-Mcfield and a microwave pulse resulted in a somewhat diffuse discharge along the particle path. (A.G.W.)

**31941** PROPERTIES OF A PARALLEL PLATE SPARK CHAMBER. Edgar F. Beall, Bruce Cork, Paul G. Murphy, and William A. Wenzel (Univ. of California, Berkeley). p.277-80 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A spark chamber was constructed of seven aluminum plates, each $\frac{1}{2}$ in. thick, separated by $\frac{1}{4}$-in. gaps. Using this device permits the trajectory of a charged particle to be observed by detecting the light produced by a spark discharge between the plates when a high-voltage pulse is applied to alternate plates. The efficiency of this chamber was measured for high-energy charged particles produced at the Bevatron. When the chamber is filled with 1 atm of neon or argon, the efficiency per gap is greater than 99% if a $\frac{1}{4}$-$\mu$sec pulse of greater than 10 kv for neon or 15 kv for argon is applied to the plates within $\frac{1}{3}$ $\mu$sec after the charged particle traverses the gap between the plates. Multiple tracks, such as those produced by a nuclear reaction in the plates, can easily be photographed. The recovery time of the chamber, after a spark discharge between the plates, is approximately 10 msec. The sensitive time is of the order of 10 $\mu$sec unless a clearing field is applied to one set of the plates. With a clearing field of approximately 160 v/cm, the sensitive time is reduced to less than $\frac{1}{2}$ $\mu$sec. When the chamber had $4 \times 10^5$ particles incident on it in 0.1 sec, three tracks per trigger were sometimes observed, in agreement with the measured sensitive time. The chamber also functioned with a magnetic field of 13 kgauss parallel to the plates. The tracks were displaced by an amount proportional to the magnetic field. In addition, if a high clearing field, E, was applied and if a long time was allowed to elapse before the high-voltage pulse was applied, the sparks in alternate gaps were displaced in opposite directions by an amount proportional to $E \times B$. Both the momentum and the time of traversal, relative to the time of applied voltage, could be determined in this manner. (auth)

**31942** FACE-VIEW PULSED SPARK COUNTER FOR VISUAL LOCATION OF RAPIDLY SUCCESSIVE PARTICLE TRACKS. Joachim Fischer and Gus T. Zorn (Brookhaven National Lab., Upton, N. Y.). p.281-3 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961. (BNL-5031)

In an attempt to record successive particle tracks during periods of about 1 msec, a spark chamber composed of an Al and a conductive-glass plate which permits a face view was constructed. Tests showed that, after a spark was first initiated following a cosmic ray through the chamber, another artificial h-v pulse produced reignition of the spark at the original position for delay times of up to 1 msec for Ar and about 0.5 msec for Ne. A second particle traversing the chamber within 1 msec not only reignited the old spark but gave rise to a new spark. (A.G.W.)

**31943** PROPOSAL FOR A SCINTILLATION COORDINATE DETECTOR. Ernst Heer (Univ. of Rochester, N. Y.). p.284-5 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A two-dimensional coordinate detector consists of two layers of closely packed but optically separated rods of scintillator. The layers are laid together with their "long aces" at right angles. A particle traversing the counter gives light signals in one rod of each layer, specifying in this way the coordinates x and y of the point of intersection of the particle path with the detector area. The use of a light-coding system is proposed in order to avoid having large numbers of photomultipliers. (A.G.W.)

**31944** A HIGH-INTENSITY $\mu$-MESON BEAM FROM THE 600-Mev CERN SYNCHROCYCLOTRON. A. Citron, C. Delorme, F. J. M. Farley, L. Goldzahl, J. Heintze, E. G. Michaelis, M. Morpurgo, and H. Oevaras (CERN, Geneva). p.286-8 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

At the CERN synchrocyclotron a beam-optical system was constructed which provides strong fluxes of $\mu$ mesons of both high and low energy with a low $\pi$-meson contamination. Two momentum analyzers separated by a decay path are used. The $\pi$ mesons are generated by the internal 600-Mev proton beam of the synchrocyclotron falling on a Be target. The first momentum analysis is effected by the magnetic field of the synchrocyclotron itself. Twenty-four equally spaced quadrupole lenses provide focusing along the 13-m decay channel. The second momentum analysis is effected by a 70° alternating-gradient magnet constructed for the purpose. (A.G.W.)

**31945** SOME FEATURES OF BEAM-HANDLING EQUIPMENT FOR THE CERN PROTON SYNCHROTRON C. A. Ramm (CERN, Geneva). p.289-98 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The construction and excitation of bending and focusing magnets for the CERN proton synchroton are described, and future beam-transport requirements are considered. Design of a parallel-plate electrostatic particle-separator system which should give $\pi^-$-antiproton separation up to

6 Bev/c is discussed. Studies on the possibility of using an r-f type of particle accelerator are reviewed. A layout of two particle ejection systems being developed is shown. (A.G.W.)

**31946** A NEW 800-Mev/c $K^-$ BEAM OF HIGH PURITY AT THE BEVATRON. Pierre Bastien (Univ. of California, Berkeley), Orin Dahl, Joe Murray, Mason Watson, R. G. Ammar, and Peter Schiein. p.299-301 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The new 800-Mev/c separated $K^-$ beam currently in operation at the Bevatron is described. Two stages of separation with parallel-plate spectrometers are used. The separators have glass cathodes heated to about 100°C in an atmosphere of Ar at about 1 $\mu$ pressure. Respects in which this beam design differs from that of previous similar beams are listed. The $K^-$ intensity at the second slit is about 15 $K^-$ per $10^{11}$ protons with a ratio of $K^-$ to total background of about 5. (A.G.W.)

**31947** RELIABILITY OF BEAM MONITORS. Franz A. Bumiller and Edgar B. Dally (Stanford Univ., Calif.). p.305-7 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

The beam monitors mainly used in connection with the Mark III linear electron accelerator are the secondary-emission monitor (SEM) and the Faraday cup. Tests of the Faraday cup indicated an absolute accuracy of better than 1%. For the SEM efficiency changes as high as 7% over a period of time were found. It was concluded that the SEM should be used as an absolute beam monitor only if frequently calibrated with a Faraday cup. (A.G.W.)

**31948** PRECISION ROTATING-COIL FLUXMETER. F. A. Bumiller, J. F. Oeser, and E. B. Dally (Stanford Univ., Calif.). p.308-9 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

In the system described for measuring magnetic fileds, two coils are rotated on opposite shafts of a motor. One coil is in the unknown field; the other coil is in a permanent magnet monitored and stabilized by nuclear magnetic resonance. Magnetic fields from zero to any practical value in nonuniform and uniform magnets can be measured. The sensitivity of the system is one part in 10,000 of the full range or one gauss whichever is greater. The system is stable to one part in 5000 over a period of 12 hr. (A.G.W.)

**31949** A TWO-SPECTROMETER SYSTEM FOR HIGH-ENERGY ELECTRON-SCATTERING STUDIES. R. Hofstadter, F. A. Bumiller, B. R. Chambers, and M. Croissiaux (Stanford Univ., Calif.). p.310-15 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

A two-spectrometer system for electron scattering is described. The system consists basically of a large magnetic analyzer and a smaller magnetic analyzer, both arranged to move around the circumference of a circle surrounding a scattering target. Details of construction of the large spectrometer are given and the performance of the entire system is described. (auth)

**31950** REMARKS ON THE USE OF A SOLENOIDAL IRON-FREE SPECTROMETER IN HIGH-ENERGY ELECTRON PHYSICS. R. Hofstadter, G. R. Burleson, A. Marcum, and W. Wadensweiler (Stanford Univ., Calif.). p.316-19 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961.

An iron-free solenoidal type of spectrometer is described for use in high-energy electron physics. The spectrometer is of the ellipsoidal du Mond type and focuses particles of 500-Mev/c momentum in a ring focus. The field employed is 20,000 gauss. The instrument and its mounting in an experimental area are described. Experiments that can be carried out with this instrument are discussed. (auth)

**31951** BEAM-VIEWING CAMERA USING RAPID-DEVELOPMENT FILM. Robert D. Sard (Univ. of California, Berkeley). p.320-1 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York, Interscience Publishers, 1961. (UCRL-9353)

To facilitate the adjustment of external beams, a beam-profile camera has been made using Polaroid Land rapid-development film. The camera contains a 5-in.-diameter, 0.88-in.-thick NaI(Tl) scintillator, a 45-deg first-surface aluminized mirror, a Nikkor N-C 50-mm f/1.1 lens, used at 4.4 : 1 reduction, and a Polaroid roll-film holder. With Type 47 film it is found that the minimum detectable exposure corresponds to about $2 \times 10^5$ pions of 180 Mev/c ($\beta = 0.785$) per $cm^2$ of scintillator, in fair agreement with an estimate using sensitometric data provided by the manufacturer. This sensitivity is sufficient to make the camera useful (exposure times in the range 1 to 10 minutes) for adjusting typical external meson beams at the 184-inch synchrocyclotron and the Bevatron. Design considerations for luminescent-beam viewing are presented. (auth)

**31952** IMPROVEMENTS RELATING TO SWITCHING DEVICES WITH A PLURALITY OF CONTACTS. (to Société Anonyme d'Etudes et Réalisations Nucléaires). French Patent 1,233,095. Oct. 12, 1960.

In reactors it is often necessary to connect, during a short time, a great number of thermocouples successively with a measuring instrument. Switching means are provided comprising a disc, on the edge of which a wheel rolls without sliding. The axle of this wheel is mounted in a support rotated by a central axle having the same axis as the disc. This support is further provided with a pin guiding a push-rod in such a way that the pin slides in a slit provided in the rod. The movement of the rod is controlled by the rotation of the wheel via a crank shaft so that a contact piece supported by the push-rod is periodically moved against a series of contact pairs arranged along a circle concentric to the disc to connect these pairs successively. (NPO)

## Materials Testing

**31953** (ANL-FGF-353) A PULSED EDDY CURRENT TEST SYSTEM USING REFLECTED FIELDS. C. J. Renken (Argonne National Lab., Ill.). June 11, 1962. Contract [W-31-109-eng-38]. 14p. (UAC-6551)

An eddy current test system is described in which the test information is detected as a series of fields reflected from the metal surface and interior. Pulsed electromagnetic fields are caused to impinge upon the test specimen. These fields are restricted to a small cross sectional area over a path in space long enough to be useful for test purposes by devices called mask-aperture assemblies. This approach provides a number of advantages over conventional eddy current methods of comparable capabilities, including superior surface resolution, a reduction in circuit complexity, and an improvement in stability and

reliability. Various applications and test results are discussed. (auth)

**31954** (D2-9518) THEORY OF RADIOLOGICAL DIFFERENTIAL INSPECTION SYSTEMS. David L. Dye (Boeing Co. Aero-Space Div., Seattle) and Kenneth L. Sinclair (Naval Radiological Defense Lab., San Francisco). Mar. 7, 1961. 29p.

Design relations of parameters in differential radiological scanning systems are discussed. The system considered comprises a radiation source, the part to be inspected, at least two continuously sensitive detectors which feed information to a differential electronic circuit, and a device for movement of the sample to allow complete examination. Optimization of conditions which should be effected by design is discussed along with the relations between flaw size, time to inspect, and source power. (J.R.D.)

**31955** (HW-72802) ULTRASONIC TESTING OF ZIRCALOY SHEATH TUBING FOR FUEL ELEMENTS. Interim Report. C. E. Fitch, H. E. May, and V. E. Kahle (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 1962. Contract AT(45-1)-1350. 89p.

A series of notches were fabricated on the outside and inside surfaces of 0.068-inch ID by 0.035-inch wall Zircaloy tubing by electromachining. Curves of ultrasonic response as a function of notch depth, notch length, metal path length, and entry angle for both the transverse and longitudinal tests are presented. The effect of notch orientation on ultrasonic response is discussed. Types and styles of transducers were partially evaluated. Techniques were developed for calibrating ultrasonic transducers using ball bearings, wires, minature receiving crystals, and optical imaging. The results of theoretical studies using Schlieren imaging techniques are discussed. Verification of theoretical Lamb-wave curves for Zircaloy using narrow frequency bands was achieved. (auth)

**31956** (HW-SA-2728) SCINTILLATION SPECTROMETRY IN NONDESTRUCTIVE TESTING. R. S. Paul (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Aug. 20, 1962. Contract AT(45-1)-1350. 36p.

A survey is made of the current state-of-the-art in scintillation spectrometry techniques and instrumentation as related to applications in nondestructive testing. Physics considerations and performance criteria are discussed. Examples are given of typical, novel, and potential applications. (auth)

# GEOLOGY, MINERALOGY, AND METEOROLOGY

*Refer also to abstracts 32255 and 32419.*

**31957** (AD-272183) CLIMATOLOGICAL PROBABILITY OF FALLOUT FROM MULTIPLE NUCLEAR DETONATIONS. Technical Report No. 162. Thomas D. Potter (Air Weather Service, Washington, D. C.). Jan. 1962. 8p.

A method of determining the climatological probability of fallout from multiple nuclear detonations is described. A general procedure for a simple case of two detonations, based on the probability of two events occurring together, was developed by applying a vector regression equation to the effective wind parameters at the two points of detonation. This was followed by an extension of the development to include three or more detonations. (auth)

**31958** (NP-12053) A FORTRAN II CODE FOR THE CALCULATION OF ELECTROMAGNETIC BLACKOUT FOLLOWING A HIGH-ALTITUDE NUCLEAR DETONATION. P. G. Fischer, R. H. Christian, and R. W. Hendrick (General Electric Co. Technical Military Planning Operation, Santa Barbara, Calif.). Dec. 29, 1961. Contract DA 49-146-XZ-038. 87p. (DASA-1292; RM-61TMP-96).

A program is presented which may be used to compute altitude, range, the electron concentration, and resulting electromagnetic absorption for specified high-altitude nuclear detonation and debris histories as functions of time. The program is written in FORTRAN II and was operated on the IBM 7090 and IBM 704; the results are in good agreement with experimental data. (J.R.D.)

**31959** (PNE-130F) HYDROLOGIC AND GEOLOGIC STUDIES FOR PROJECT GNOME. Progress Report. (Geological Survey, Washington, D. C.). May 1962. 197p.

Project Gnome is a multiple-objective experiment conducted by the U. S. Atomic Energy Commission as a part of the Plowshare Program to develop peaceful uses for nuclear explosives. The experiment consisted of the explosion of a nuclear device at a depth of about 1,200 feet below the surface in a thick salt deposit about 25 miles southeast of Carlsbad, New Mexico. The Gnome site is at the approximate center of sec. 34, T. 23 S., R. 30 E., Eddy County, N. Mex. The U. S. Geological Survey made scientific studies and investigations related to Project Gnome largely with respect to public safety aspects. Basic geologic and geophysical information is presented that is needed to define the pre- and post-shot geologic and physical properties of the salt and other rocks affected by the explosion, and geologic and hydrologic information on the pre- and post-shot hydrologic conditions at the Gnome site and surrounding region. (auth)

**31960** (RM-3288-PR) DECAY OF IONIZATION IMPULSES IN THE D AND E REGIONS OF THE IONOSPHERE. C. M. Crain (RAND Corp., Santa Monica, Calif.). Sept. 1962. Contract AF49(638)-700. 8p.

A memorandum is presented in which results are presented concerning the decay of ionization in the D and E regions of the ionosphere following an impulse of ionization from space such as nuclear burst-induced x rays. Previous results were presented for 75, 95, and 115 km, and values were given for the approximate times required for impulses of from $10^3$ to $10^4$ electrons/cc to decay to $\frac{1}{2}$ of the initial value. The previous calculations are extended to cover the range of 55 to 115 km, and the full decay characteristics are presented for impulses in the range $10^3$ to $10^4$ electrons/cc. (J.R.D.)

**31961** REPORT TO THE FEDERAL COUNCIL OF THE FEDERAL COMMISSION FOR MONITORING OF RADIOACTIVITY. P. Huber. Bull. Eidgenoss. Gesundh., Beil. B., 15: 1-28(July 1961). (In German and French)

The results of measurements of the radioactivity of the air, precipitations, and surface waters in Switzerland from October 1959, to December 31, 1960, are reported in tabular form. (J.S.R.)

**31962** COAL AS A SOURCE OF BERYLLIUM. J. Jedwab (Institut Interuniversitaire des Sciences Nucléaires, Brussels). Bull. soc. belge geol., paleontol. et hydrol., 69: 67-77(1960). (In French)

A summary is given of the most important works on coal as a possible source of Be. The fifteen references cited show the existence of coals with important Be concentrations. The possibility of the eventual utilization of coal ash as a Be ore is indicated. (J.S.R.)

**31963** PRESENCE OF BERYLLIUM IN CERTAIN BELGIAN COALS. J. Jedwab (Institut Interuniversitaire des Sciences Nucléaires, Brussels). Bull. soc. belge geol., paleontol. et hydrol., 69: 77-82(1960). (In French)

A study of spectrograms of many Belgian coals shows the existence of Be. The data tabulation does not attempt to give a precise quantitative evaluation, but it does permit some conclusions to be drawn. Strata rich in Be are rare, and the coals which are richest in Be have the lowest ash content. Be is rarely absent from any of the coals. (J.S.R.)

**31964** DISTRIBUTION OF BERYLLIUM IN CERTAIN COAL STRATA OF BONNE-ESPÉRANCE À LAMBUSART. J. Jedwab (Institut Interuniversitaire des Science Nucléaires, Brussels). Bull. soc. belge geol., paleontol. et hydrol., 69: 227-34(June 1960). (In French)

Spectrochemical analyses have shown the constant presence of Be in the coals of Bonne-Esperance at Lambusart. The values vary between 20 and 500 ppm in the ashes, for a mean of 200 ppm. Regularities of the distribution of Be (effect of the concentration in the ash and proximity of walls) can be tentatively determined from the small number of available data. (tr-auth)

**31965** MOUNTING OF ROCKS ON RETICULATED SLIDES FOR LOCATION OF ALPHA EMITTERS. J. Jedwab (Université Libre, Brussels). Bull. soc. belge geol., paleontol. et hydrol., 70: 24-7(1961). (In French)

The technique used in mounting rock on reticulated glass slides and exposure of nuclear plates to determine the location of $\alpha$ emitters is described. An example of the application of this technique is given to show its possibilities. (J.S.R.)

**31966** MONITORING OF WATER AND ENVIRONMENTAL RADIOACTIVITY IN FRANCE. Gerhard W. Stroehl (Centre d'Etudes Nucléaires, Fontenay-aux-Roses, Paris). Deut. gewässerkundl. Mitt., 5: 92-5(Aug. 1961). (In German)

As an introduction to a report of radioactivity monitoring in France, the organization of the French service devoted to radioactivity monitoring is described. The results obtained in the determination of the $Sr^{90}$ concentration in river and sea water and the determination of Ra in river, sea, and mineral waters are given. The methods used in both determinations are briefly indicated. (tr-auth)

**31967** NEW DATA ON RADON WATERS OF BYELAYA TSERKOV DISTRICT. A. G. Bondar (Inst. of Geology,

Academy of Sciences, Ukr. SSR). Dopovidi Akad. Nauk. Ukr. R.S.R., No. 6, 789-92(1962). (In Ukrainian)

The radon waters of Byelaya Tserkov district are associated with the fissure zone of the pink medium-grained granites of the Bug-Dnieper type connected with processes of depth weathering. By their chemical composition these are hydrocarbonate-calcium-magnesium waters of low mineralization; in respect to radon content, they are of high and, in some springs, of weak radioactivity. (auth)

**31968** ISOTOPIC BORON COMPOSITION OF CERTAIN BORON MINERALS. H. O. Finley, A. R. Eberle, and C. J. Rodden (U. S. Atomic Energy Commission, New Brunswick, N. J.). Geochim. et Cosmochim. Acta, 26: 911-14(Sept. 1962). (In English)

Possible variation in the natural boron isotopic abundance was investigated by analyzing seven boron minerals from various parts of the world. The samples were treated to yield sodium tetraborate with a 100% recovery of the boron, and the tetraborate was analyzed with a surface ionization mass spectrometer. The $B^{11}/B^{10}$ ratio was found to vary from 3.922 for an Argentinian sample to 4.141 for a Russian sample. It is suggested that the variation may be due to chemical effects. (D.L.C.)

**31969** THE ISOTOPIC COMPOSITION OF STRONTIUM AND THE AGE OF STONE METEORITES. [PART] I. Paul W. Gast (Univ. of Minnesota, Minneapolis). Geochim. et Cosmochim. Acta, 26: 927-43(Sept. 1962). (In English)

New measurements of the Rb and Sr content and Sr isotope composition are reported for four Ca-rich achondrites and five bronzite or hypersthene chondrites. All the achondrites have identical $Sr^{87}/Sr^{86}$ ratios; one chondrite, Beardsley, is very much enriched in Rb relative to the other chondrites. Several alternative interpretations of the data are discussed; all agree on a period of chemical differentiation 4.3 to 4.7 Aeons ago (Aeon = $10^9$ yrs) in the parent body of the meteorites. (auth)

**31970** ZIRCONIUM, NIOBIUM AND CERTAIN OTHER TRACE ELEMENTS IN SOME ALKALI IGNEOUS ROCKS. J. R. Butler and A. Z. Smith (Imperial Coll. of Science and Tech., London). Geochim. et Cosmochim. Acta, 26: 945-53(Sept. 1962). (In English)

The elements Rb, Sr, Y, Zr, Nb, and Ta were determined in a variety of alkali igneous rocks and concentration values are compared with those found in some of the Younger Granites of N. Nigeria. Na-rhyolites, comendites, pantellerites, and related rocks from different localities show some close similarities. Nb and Ta both tend to become enriched in (these) late stage differentiates and can exceed 200 ppm and 10 ppm respectively; Zr is similarly high and can exceed 2000 ppm. There is appreciable variation in the K/Rb ratio but less in that of Nb/Ta for rocks from the same petrographic province. Data for acid rocks containing Na-amphibole are compared. Nb increases as Sr decreases and becomes conspicuous when Sr is below the detection limit of 40 ppm; this tends to correspond to the appearance of riebeckite. In contrast, Sr and Nb can both be high in under-saturated alkali plutonic and volcanic rocks. (auth)

**31971** GAMMA-SPECTROMETRIC ACTIVATION LOGGING. Yu. P. Bulashevich, I. N. Sen'ko-Bulatnyi, and L. L. Deev (Inst. of Geophysics, Academy of Sciences, USSR). Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., No. 9, 1153-7(1962). (In Russian)

Neutron-activation logging of Cu and bauxite deposits, using a three-strand cable scintillation spectrometer, is described. Cu, Mn, and Al spectra developed by activation logging in a bore hole and results from logging copper and bauxite deposits show the importance of carefully considering interfering elements. (R.V.J.)

**31972** VARIATIONS OF NATURAL AIR RADIOACTIVITY AT THE VALLEY LEVEL OF THE NORTHERN DOLOMITE ALPS. Reinhold Reiter. Meteorol. Rundschau, 10: 2p. (1957). (In German)

In order to determine whether large variations of the natural air radioactivity occurs at the valley level of the Northern Dolomite Alps, measurements were carried out from April to November 1956 on rainless days at the valley station for Farchant. The results obtained are shown graphically as a function of the mean wind direction over the Alpine crest. The results show clearly how the accumulation range of the measurement points for the individual principal directions are shifted to the southern half as the wind rose according to high radioactivity values. The results also show that extreme fluxations of the natural air activity are very frequent at the valley level. These results show that the natural radioactivity permits extensive investigations of wind and circulation behavior. The observations also have significance for health climatic, and bioclimatic questions. The fluxations found in the natural air radioactivity indicate corresponding variations of the ionization. (J.S.R.)

**31973** AGE OF LUNDY GRANITE, BRISTOL CHANNEL. M. H. Dodson and L. E. Long (Oxford Univ.). Nature, 195: 975-6(Sept. 8, 1962).

An unweathered granite specimen of the intrusive phase was collected from the southeast side of Lundy, a small island in Bristol Channel. K-Ar and Rb-Sr isotopic age measurements were made on separate biotite, a representative sample of whole rock, and a slate sample from Lundy. The K-Ar and Rb-Sr ages of the biotite were found to be $52 \pm 2$ m.y. The problems encountered in the interpretation of the age data are discussed in some detail. It is concluded that the Lundy granite is the most southerly known Tertiary igneous center of the North Atlantic Province. (D.L.C.)

**31974** THORIUM AND URANIUM CONTENTS OF AUSTRALITES. R. D. Cherry (Univ. of Cape Town). Nature, 195: 1184-6(Sept. 22, 1962).

The Th and U contents of six australites (two from Victoria, two from South Australia, and two from western Australia) were measured with the "thick-source" alpha counting and thorium-A pairs methods. The contents were found to fall in the ranges of 8.1 to 11.6 and 1.4 to 2.4 ppm for Th and U, respectively. A positive correlation between the count rate and the K content was found. The implications of the small spread in the Th and U contents over the six tektites are discussed. (D.L.C.)

**31975** STUDIES ON MEASUREMENT OF FLOW RATE OF RIVER STREAM USING RADIOACTIVE TRACERS. Masao Kato, Kunitaro Kawazoe, and Otomaru Sato (Tokyo Univ.). Radioisotopes (Tokyo), 11: 23-32(Feb. 1962). (In Japanese)

Applications of radioisotopes as tracers for flow measurements of rivers are discussed. Results are reported from field experiments using about 1 c of $I^{131}$ or about 0.4 c of $Na^{24}$ as tracers. Direct measurements were made under water and samples were collected periodically downstream. Data on concentration versus time of flow were plotted. The maximum distance traced by 60 mc of $Na^{24}$ was about 30 kilometers. (C.H.)

**31976** DETERMINATION OF THE TROPOSPHERIC RESIDENCE TIME OF LEAD-210. L. M. Fry and K. K.

Menon (Univ. of Arkansas, Fayetteville). Science, 137: 994-5(Sept. 21, 1962).

The ratios of bismuth-210 to lead-210 in rain samples were used to calculate tropospheric residence time for lead-210. The value of about 6 days thus obtained agrees closely with the average interval between two rainfalls. (auth)

**31977** RECONNAISSANCE FOR RADIOACTIVE MINERALS. Carlos Goncalves (Junta de Energia Nuclear, Lisbon). Technica, No. 304, 543-60(1960). (In Portuguese)

Radioactive reconnaissance is the first step in prospecting for radioactive minerals. It is a method for locating sites for more extensive prospection. Reconnaissance using automobiles is preferable to the use of airplanes. The apparatus used in such reconnaissance are briefly described. (J.S.R.)

**31978** RECENT RESULTS FROM ALPINE AIR RADIOACTIVITY MEASUREMENTS. R. Reiter (Universität Munich). Zentr. Biol. Aerosol Forsch., 9: 195-219 (1960). (In German)

By means of various diagrams, the transient pattern of the natural and artificial radioactivity and of air impurities in 1959 at a valley and a neighboring mountain station was represented and described. It was shown that the air layer near the ground added more long-lived radioactive substances by repeated eddying up from the ground than from greater heights. The daily pattern of the components of the air radioactivity at the mountain and valley stations was described. The effect of vertical temperature gradients on the vertical distribution of natural and artificial radioactive substances was thoroughly represented. Conclusions on the half-value height of the natural radioactive elements and therefore on the velocity of vertical material exchange were given. The application to the estimation of the transport velocity of contaminated particles from the mountain to the valley was indicated. From the vertical concentration variation of the RaB, the exchange coefficient was calculated as a function of temperature stratification. The correlation between natural or artificial air activity and relative humidity, as well as air pollution, was described by means of diagrams. Whereas natural radioactive particles were bound to the large aerosols of the valley air, artificial radioactive elements were not. These were especially concentrated by atmospheric descending movements at the mountain station. The activity values originating in the passage of a radioactive cloud from the French atomic research in the Sahara were described using some motion diagrams. (tr-auth)

**31979** SOME RESULTS ON THE BEHAVIOR OF THORIUM B IN THE LOWER ATMOSPHERE FROM MEASUREMENTS AT A VALLEY AND MOUNTAIN STATION OF THE NORTHERN ALPS. Reinhold Reiter (Universität Munich). Zentr. Biol. Aerosol Forsch., 9: 448-67(1961). (In German)

After a discussion of the various half lives of radon and thoron decay products and their significance in vertical distribution in the upper atmosphere, the monthly average and monthly extremes of ThB concentrations measured in the air at the Farchant Station (675 m NN) and at the mountain station Wankgipfel (1780 m NN) were reported in tabular form for the year 1959 and the first half of 1960. The table contains, for comparison, the simultaneously measured values of the RaB concentration and the concentration of fission products in the air. It is shown that after a decay time of 48 hrs., under certain circumstances, significant masses of ThB and decay products still remain on the exposed filters, which can more or less strongly impair the determination of the fission products. This is no longer the case after a decay time of 120 hrs. The annual trend of the ThB concentration deviates significantly from that of the RaB concentration. The type of deviation leads to the conclusion that the ThB formed in the valley can not reach the mountain station. The vertical motion is much too long in comparison with the decay time of the ThB. Also the daily pattern of the ThB deviates significantly from that of the ThB. The minimum on ThB was measured at night, in contrast to the RaB. This indicates that a given minimum turbulence in the air layer near the ground is necessary in order to eddy up the ThB reproduced only directly at the earth surface. The comparison of the ThB concentration with the wind velocity leads at both stations to the same results. A relationship between ThB and the relative humidity as well as the degree of air pollution could be detected at neither of the stations. Sharp increases of the ThB level were observed at the time of the snow melting, whereas in the winter the ThB concentration is very low because of the impedance in exhalation. It is assumed that the ThB emission from near mines yields a noticeable contribution. (tr-auth)

**31980** COAGULATION, DECAY AND RESIDENCE TIMES OF FISSION PRODUCTS IN THE ATMOSPHERE. M. Hinzpeter. Zentr. Biol. Aerosol Forsch., 10: 1-96 (Oct. 1961). (In German)

Aerosol radioactivity measurements made at various times and places since 1954 are used to determine the coagulation decay and resonance times of fission products in the atmosphere. The daily, yearly, and weekly behavior of stable and radioactive particles near the earth's surface is discussed and shown graphically. The mechanisms for coagulation and decomposition process in the stratosphere are reviewed. The methods used for the age determination of fission products are described, and their resonance time in the stratosphere are determined. (J.S.R.)

**31981** TEMPERATURE DEPENDENCE OF EMANATION OF MINERALS. N. S. Strashnikov and N. Z. Nasyrova. p.3-13 of "Optika. Yadernye Protsessy." Alma-Ata, Kazakh SSR, 1959.

The temperature dependence of the emanation by uranium black, uraninite, and zircon of Rn, Tn, and An under different conditions of heating (20–1000°C, 3–60 min) was studied. As a rule, $K_{em}$ rises with rising temperature, but maxima are observed at several intermediate temperatures. For uranium black, the maximum $K_{Rn}$ lies at 200 and 650°C; for uraninite, the maximum $K_{An}$ lies at 900°C; and for zircon, the maxima of $K_{An}$ and $K_{Tn}$ lie at 600°C. After repeated heating, the maxima no longer appear, which is due to irreversible changes of the crystal lattice. Emanation of a preheated mineral at room temperature is only some tenths of the emanation of nonheated mineral, which is connected with the elimination of crystal lattice defects. For uraninite, the irreversible change takes place at 300°C. (Referativnyy Zhurnal, Khimiya, No. 19, 1961.)

**31982** NATÜRLICHE UND KÜNSTLICHE RADIOAKTIVITÄT IM GEBIRGE. STUDIEN UBER AUSMASS UND URSACHEN ZEITLICHER WIE ÖRTLICHER VARIATIONEN DER RADIOAKTIVITÄT DES AEROSOLS IN DEN NORDALPEN UND DEREN AUSWIRKUNGEN AUF DIE RADIOAKTIVITÄT VON NIEDERSCHLAGEN, SCHNEEOBERFLÄCHEN UND GRÄSERN. (Natural and Artifical Radioactivity in the Highlands. Studies of the Extent and Origin, and Variations with Time and Location of Radioactivity of Aerosols in the Northern Alps and Their Effects on Radioac-

tivity of Precipitation, Snowfall, and Grasses.) Reinhold Reiter. Stuttgart, Friedrich-Karl Schattauer-Verlag, 1960. 79p.

A complete and clear report is given of studies made over a period of several years of the natural and artificial radioactivity aerosol in the Alps. The transient and spatial variations of the aerosol activity and their relationships to local and regional meteorological processes and conditions were studied. Special emphasis was given to problems present in the Alpine region, to the solution of these problems, and to those results which have more than regional significance. The measurements made were determinations of the artificial and natural air radioactivity, of the air impurities, of the artificial radioactivity in precipitation and grasses, and the radioactive deposition from snow and ice surfaces. The measurement results are shown in tabular and graphical form and the practical consequences are discussed. (J.S.R.)

# HEALTH AND SAFETY

*Refer also to abstracts 31428 and 32036.*

**31983** (AHSB(RP)-R-15) THE INTERPRETATION OF DATA ON RADIONUCLIDES IN URINE. PART I. URANIUM. S. Jackson (United Kingdom Atomic Energy Authority. Authority Health and Safety Branch, Radiological Protection Div., Harwell, Berks, England). July 1962. 23p.

The interpretation of data on uranium content in urine samples is discussed in the light of calculations based on human and animal experiments. In the case of insoluble uranium compounds, the critical hazard is radiological exposure of the lungs. With soluble compounds of highly enriched uranium the primary hazard is also radiological, due to the slow removal of uranium which is deposited in bone; for soluble compounds of highly enriched uranium the critical organ is therefore the bone, not the kidney. It is suggested that for these radiological cases the degree of hazard is best assessed by estimations of the chronically-retained body burden by reference to after-holiday or after-weekend samples, not to shift samples. Maximum permissible urine concentrations recommended for after-holiday samples were calculated from ICRP parameters; the figures for the cases of soluble and insoluble uranium are almost identical. The relationship between urinary excretion and retained body burden for periods of up to 30 days after a single intake of uranium was also calculated directly from observations on human metabolism of uranium. For a given urinary excretion, the estimates are lower than those for the chronically retained body burden, as calculated from ICRP parameters. (auth)

**31984** (HW-SA-2514) SHIPMENT OF GROSS QUANTITIES OF RADIOSTRONTIUM. L. L. Zahn, C. W. Smith, R. L. Junkins, and E. C. Watson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [Aug. 13, 1962]. Contract AT(45-1)-1350. 15p.

The development, design, and appraisal of shipping systems which are or have been used for the shipment of $Sr^{90}$ are discussed. Data are tabulated on the shipment of 1.5 Mc of $Sr^{90}$ from Hanford to various destinations within the U.S. in one of three basic systems. It is pointed out that $Sr^{90}$ is a heat producing, $\beta$-emitting nuclide of 28-year half-life, that it may enter man by ingestion or inhalation, that it is deposited in bone, and that the mean skeletal dose of $Sr^{89}$ and $Sr^{90}$ should not exceed 0.5 rem a year. This level corresponds to a contamination level of about 0.6 $\mu c/m^2$ of combined $Sr^{89}$ and $Sr^{90}$. The hazards from accidental spills of $Sr^{90}$ are discussed. Special shipping casks for $Sr^{90}$ are described in detail. (C.H.)

**31985** (HW-SA-2655) DESIGN VERIFICATION TEST PROGRAM, HANFORD DESIGNED SHIPPING SYSTEMS. L. L. Zahn and R. L. Junkins (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). July 5, 1962. Contract AT-(45-1)-1350. 31p.

The Hanford cask testing program for design verification of certain critical features of the HAPO-I and II type shipping systems is described. The casks are used for $Sr^{90}$ shipments. The cask system has three primary components: the product filter container, the cask proper, and the cask container. Design criteria for normal and emergency conditions are described. Model-scale testing was used. (M.C.G.)

**31986** (HW-SA-2718) RADIOACTIVITY IN ALASKAN ESKIMOS. H. E. Palmer, W. C. Hanson, B. I. Griffin, and W. C. Roesch (General Electric Co. Hanford Atomic Products Operations, Richland, Wash.). Aug. 17, 1962. Contract AT(45-1)-1350. 21p.

The body burdens of 700 Eskimos from various locations in northern Alaska were measured during the summer of 1962. No isotopes other than $Cs^{137}$ and $K^{40}$ were detected in the Eskimos except for 2 subjects who had a few nanocuries of $Zn^{65}$. It was found that these people occasionally ate canned oysters, which probably led to the $Zn^{65}$ burdens. External body contamination, mainly $Zr\text{-}Nb^{95}$, was frequently noticed. Differences in body burdens of Kotzebue, Point Hope, and Barrow Eskimos were accounted for by differences in their diets. (P.C.H.)

**31987** (K-1550) THE EFFECT OF URANIUM DENSITY ON THE SAFE U-235 ENRICHMENT CRITERION. C. E. Newlon (Oak Ridge Gaseous Diffusion Plant, Tenn.). Oct. 11, 1962. Contract W-7405-eng-26. 20p.

A review of the density effect on the criticality of low enrichment U indicated that the nuclear homogeneity of fissionable materials, considered under the safe enrichment criterion of 0.95% $U^{235}$, should be established for nuclear safety. It appears that a condition of nuclear homogeneity will be maintained if the U density is less than or equal to 3.2 g $U/cm^3$, or for densities ranging from 3.2 g $U/cm^3$ up to a maximum of 18.9 g $U/cm^3$. One dimension of the U fuel is less than or equal to 0.02 in. (auth)

**31988** (CEA-tr-R-1489) RÈGLEMENTS SANITAIRES DES TRAVAUX SUR LES PRODUITS RADIOACTIFS ET LES SOURCES DE RAYONNEMENTS IONISANTS. (Sanitary Regulations in Handling Radioisotopes and Ionizing Radiation Sources). M. Nikitin (Nikitine) and V. Emilianov (Emilyanov) (U.S.S.R. Sovet Ministrov. Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii). Translated into French. 1960. 164p.

The safety rules that must be followed by all laboratories, services, and warehouses that handle or store radioisotopes or radiation sources are presented. (J.S.R.)

**31989** (FTD-TT-62-678) THE POSSIBILITY OF USING CERTAIN ORGANIC SCINTILLATORS FOR DOSIMETRY. Yu. A. Yegorov and V. A. Kucheryaev (Kucheryayev). Translated from Inzhener.-Fiz. Zhur. Akad. Nauk Belorus. S.S.R., 4: No. 7, 117-19(1961). 7p.

Experiments were conducted and calculations made to evaluate the possibility of using liquid and plastic scintillators for dosimetry of $\gamma$-radiation and fast neutron fluxes. It was concluded these scintillators can be used; their dosimetric reactions for measuring $\gamma$-radiation are no worse than in air-filled Al-wall ionization chambers and their sensitivity is considerably higher at smaller volumes. Measurement of fast neutrons in a $\gamma$-radiation background can be accomplished by the proper arrangement of two instruments. (J.R.D.)

**31990** LEUKEMIA AS COMPENSABLE RADIATION INJURY. A PLAN FOR INSURANCE AGAINST LATE SEQUELAE OF SMALL IRRADIATIONS. R. R. Newell (Naval Radiological Defense Lab., San Francisco). Arch. Environmental Health, 5: No. 2, 129-33(Aug. 1962).

Besides the gross immediate industrial accidents that occur in nuclear industry, there are the delayed injuries to health, which can best be indemnified by some sort of insurance. The best understood of these late sequelae of irradiation is leukemia. A scheme for reasonable compensation for leukemia is presented. It would cost the em-

ployees about $\frac{1}{20}$ of 1% of their pay and cost the employer about 0.001% of the payroll. Indemnification for the other late sequelae, cancer and life shortening, could be managed in similar fashion. The exposure to risk is not a compensable injury unless or until it eventuates in injury. (auth)

**31991** STUDIES ON RADIOACTIVATION BY A COBALT-60 γ-RAY SOURCE. IV. STUDIES ON INDIUM DOSIMETRY. Kenji Yoshihara. Dôitai to Hôshasen, 4: 93-101(Jan. 1962).

Indium dosimetry using the $In^{115}(\gamma,\gamma)In^{115m}$ reaction appeared to be useful for measuring the dosage rate above $10^7$ r/hr and at low temperatures. Using the theories of spherical and nonspherical sources, the dosage rate (D in r/hr) at a given position could be calculated from $D = 4.57 \times 10^{-28} A_s B/\sigma$, where $A_s$ is the saturated radioactivity produced/g of In, B is the dosage build-up factor, and $\sigma$ is the over-all cross section. It is recommended that calculation diagrams for B and $\sigma$ be used in order to simplify the calculation. Tabular data from a series of measurements in the vicinity of the 10-kc $Co^{60}$ γ-source using the In dosimetry method, were in accord with data obtained by means of the Victoreen roentogen meter for Ce dosimetry. The percentage of error exceeded 20%. (OID)

**31992** A SIMPLE DOSIMETER UTILIZING PHOTOSENSITIVE SOLID DYE. Yoichi Chitani and Yoshihide Naito. Dôitai to Hôshasen, 4: 132-3(Jan. 1962).

A simple color dosimeter was devised by painting a glass plate ($2 \times 2$ $cm^2$) with a new dye. When the plate was x irradiated, it would change from light pink to dark purple-red depending upon the dosage level. Hence, the x-ray dose range of $10^4$ to $10^5$ r could be estimated with an accuracy of $\pm 1 \times 10^4$ r. However, the dosimeter was not applicable to γ-ray sources because the fluorescence emitted from calcium tungstate was too weak to cause a marked change in the dye. (OID)

**31993** LEGAL BASIS AND PERSONAL RESPONSIBILITY FOR RADIATION PROTECTION IN NUCLEAR MEDICINE. C. Winkler (Universitatsklinik Bonn). Med. Klin. (Munich), 56: 2113-16(Dec. 1961). (In German)

In the therapeutic and diagnostic investigations with radioisotopes, the problem of radiation protection for the patient and for the radiologist is of primary importance. The legal responsibilitiy of the radiologist is still undefined, but his responsibility must not be underrated. Some examples are given which show how the radiologist and the patient are protected during treatment and diagnosis. (J.S.R.)

**31994** ORGANIZATION IN ACTS OF THE FIAT FOR CONTROL OF PERSONNEL EXPOSURE TO IONIZING RADIATION FOR PROFESSIONAL PURPOSES. Luigi Pizzi (Sezione Energia Nucleare della FIAT, Turin). Minerva fisioterap., 4: 10p.(July-Aug. 1959). (In Italian)

The provisional organization set up along the lines of the impartial Euratom directive to ensure the protection of professional personnel exposed to radiation is described. The make-up of this organization, the work done, and the problems to be studied are indicated. (J.S.R.)

**31995** RADIATION HYGIENE IN AND AROUND A NUCLEAR POWER STATION. J. H. Martin (United Kingdom Atomic Energy Authority, Annan, Scotland). Nature, 195: 1145-50(Sept. 22, 1962).

The operating experience of the four Calder Hall reactors at Chapelcross is discussed in relation to radiation safety. The cycle of operations is described briefly. Personnel protection measures are outlined, and dose records are given which show that charge/discharge operations are not the principal cause of exposure of personnel. Results of air and surface contamination surveys are given. The environmental monitoring program is outlined, and monitoring results are given for soil, grass, milk, seaweed, sand, and shrimps. (D.L.C.)

**31996** THE FLUOROGLASS DOSIMETER. Ryosuke Yokota, Saburo Nakajima, and Hideo Osawa. Toshiba Review (Japan), No. 9, 41-8(1962).

Test results with respect to the advantages of a new fluoroglass dosimeter, FD-1, composed of 50 $LiPO_3$ and 50 $Al(PO_3)_3$ with additional 3 $B_2O_3$ and 7 $AgPO_3$ by weight percentage were compared with other glasses. The features of an ideal personnel monitoring device ($8 \times 8 \times 4.7$ mm in size covered with an 1.2-mm thick Sn filter) are summarized as follows: the energy dependence from 120 kv to 2 Mev for γ-rays, its fading from 10 mr to 10 r, and its direction dependency can be ignored; it had an extremely small predose; its percentage of error was from 5 to 10%; its constant sensitivity could be maintained by compensating for the temperature and instrument variations with a standard glass; it was most suitable for obtaining an accumulated exposure dosage over a long period; it had excellent sensitivity to thermal neutrons; and the depth dosage was measured by means of a glass rod ($1 \times 6$ mm). (OID)

**31997** CRITICALITY ACCIDENT AT THE Y-12 PLANT. Gould A. Andrews, Beecher W. Sitterson, Arthur L. Kretchmar, and Marshall Brucer (Oak Ridge Inst. of Nuclear Studies, Tenn.). p.27-48 of "Diagnosis and Treatment of Acute Radiation Injury." Geneva, World Health Organization, 1961.

On June 16, 1958, a criticality accident occurred at the Y-12 plant in Oak Ridge, Tenn. Five men received high dose levels of neutron and γ radiation. Dosimetry procedures, clinical observations, and methods of treatment are described. (C.H.)

**31998** DOSIMETRIC CONSIDERATIONS IN CRITICALITY EXPOSURES. J. A. Auxier (Oak Ridge National Lab., Tenn.). p.141-50 of "Diagnosis and Treatment of Acute Radiation Injury." Geneva, World Health Organization, 1961.

Problems involved in radiation dosage determinations for persons exposed to critical assemblies are discussed. Dosimetry studies are described that were made on men exposed as a result of the Oak Ridge Y-12 accident and the excursion of the zero power reactor at Boris Kidric Institute at Vinca, Yugoslavia. Methods used in determinations of neutron and gamma doses are described in detail. (C.H.)

**31999** WATER POLLUTION AND WATER PURIFICATION (INCLUDING RADIOACTIVE CONTAMINATION AND DECONTAMINATION). OTS Selective Bibliography. (Office of Technical Services, Washington, D. C.). July 1962. 13p. (SB-498). $0.10(OTS).

References (179) on water pollution and purification and radioactivity in water are given to reports, journals, translations, and patents published from 1935 to July 1962. (P.C.H.)

# INDUSTRIAL APPLICATIONS OF ISOTOPES AND RADIATIONS

**32000** (ARF-1166-22) STUDIES OF NUCLEAR RESONANT ABSORPTION OF GAMMA RAYS. Final Report. James J. Ezop (Illinois Inst. of Tech., Chicago. Armour Research Foundation). May 1, 1962. Contract AT(11-1)-578. 93p.

The feasibility of employing the Mössbauer resonant absorption phenomenon for new and useful applications of radioisotopes was studied and evaluated. For these experimental studies radioactive $Co^{57}$ sources were used which allow observations of the Mössbauer resonance in $Fe^{57}$ at room temperatures. However, the results of the investigations can be extrapolated to other Mössbauer isotopes which, unfortunately, usually require low-temperature apparatus to obtain an appreciable fraction of recoilless emissions and absorptions. The investigations centered around the utilization of the Mössbauer effect for practical problems in measurement and control technology. The use of nuclear resonant techniques in the general areas involving small velocity, acceleration, and displacement measurements appears very promising. For example, velocities in the range from 0.005 to 0.015 cm/sec are easily measured using $Fe^{57}$ nuclear resonance, and this range can be extended several orders of magnitude in both directions if other sources and techniques are employed. Measurements of gravitational fields in interplanetary space or on the surfaces of celestial bodies, together with altitude measurements of space vehicles, using Mössbauer techniques do not appear practical because the measurement times required to obtain reasonably accurate results is of the order of hours or days under the most favorable circumstances. Experimental measurements of the effects of high pressures on the fractional resonant absorptions showed no observable changes when a $Co^{57}$-stainless steel source was subjected to pressures up to 40,000 psi, although higher pressures or other Mössbauer sources may make pressure measurements practical. Experiments showed that it is possible to determine the direction and strengths of homogeneous magnetic fields in a range from 300 to 1000 gauss by measuring the percentage of nuclear resonance in iron foils. Although the method is not, in general, as accurate as conventional techniques, such a system warrants further study since it might have definite practicality when hostile environments or accessibility problems limit or prohibit the use of conventional techniques. Initial studies also showed that nuclear resonance techniques could be used to measure the amplitudes of acoustical (mechanical) motion in the megacycle frequency region. The results gave every indication that such measurements could be extended to higher frequencies and possibly into the hypersonic, kilo-megacycle ranges where currently there are no suitable methods available to measure acoustical power or acoustical energy densities. (auth)

**32001** (IA-730) APPLICATION OF RADIOISOTOPES IN LUMINOUS DEVICES. PART I. SURVEY OF SELF-ILLUMINATING SYSTEMS. A. Heller and M. Anbar (Israel. Atomic Energy Commission, Tel Aviv). July 1962. 10p.

The formation of self illuminating systems by various radioisotope and phosphor combinations is described. (auth)

**32002** (NP-12062) PEACH DIET—REPORT OF OBSERVATIONS [ON] METABOLISM AND NUTRITION: SUBTASK, RADIATION AND STERILIZATION OF FOODS FOR OREGON STATE COLLEGE, CORVALLIS, OREGON. M. A. Ross (Armed Forces Inst. of Pathology, Washington, D. C.). Mar. 15, 1962. 45p.

Histologic studies were made on the effects of long term feeding of irradiated peaches on 134 rats. The peaches were irradiated at 2.79 and 5.58 megarad, referred to as 1X and 2X, respectively. Unirradiated peaches, referred to as 0X, were used for control diet. The only differences, disregarding sex, arose from a greater incidence of bone marrow lesions in the control animals as compared to those fed irradiated peaches. Tumors or lesions of general or specific types in the pancreas, pituitary, and adrenal glands were associated with females rather than males. The reverse was true of lesions in the liver, urinary bladder, mesenteric lymph nodes, and the thyroid gland. Interstitial lesions in the kidneys were more prevalent in the control and 2X groups than in the 1X group but there were no significant differences when control animals were compared to 2X animals. It was concluded that the ingestion of irradiated peaches by rats, under the conditions studied, produced no data that could be considered as unequivocally attributable to the ingestion of irradiated peaches. (auth)

**32003** (NP-12063) REPORT OF OBSERVATIONS [ON] METABOLISM AND NUTRITION: SUBTASK, RADIATION AND STERILIZATION OF FOODS FOR UNIVERSITY OF CALIFORNIA, LOS ANGELES, CALIFORNIA. M. A. Ross (Armed Forces Inst. of Pathology, Washington, D. C.). Jan. 31, 1962. 39p.

Investigations were made on the feeding of unirradiated or irradiated bacon and fruit compote to rats in a double feeding program. Two levels of irradiation were used: low level (1X) and high level (2X). One diet (both foods at 1X) was closely analyzed for any indication of an effect of the 1X level of irradiation. In most instances, the control animals showed as great or greater incidence of lesions than did the test groups. Although this implies that the factor of irradiation of foods prevented, to some degree, the development of lesions, it is not a definite conclusion. The few instances wherein statistical associations were noted often involved the diet in which the animals received both foods irradiated at the low level. Other associations were scattered and no consistent pattern was found that indicated that foods irradiated at the 2X level were the prime contributing factor. (P.C.H.)

**32004** (NP-12064) REPORT OF OBSERVATIONS [ON] METABOLISM AND NUTRITION: SUBTASK, RADIATION AND STERILIZATION OF FOODS FOR DEPARTMENT OF ANIMAL HUSBANDRY, CORNELL UNIVERSITY, ITHACA, NEW YORK. W. E. Tucker, Jr. (Armed Forces Inst. of Pathology, Washington, D. C.). Mar. 15, 1962. 7p.

The effects of diets of irradiated tuna fish or corn on dogs was studied. Conclusions were based only on the tabulation of incidence of lesions; no statistical tests were made. With the exception of a chondrosarcoma of the scapula in one dog and unilateral testicular atrophy in another, the lesions in the dogs were mild and of minor

degree. It was concluded that the consumption of irradiated tuna fish or corn produced no histopathologic change in dogs that can be attributed to the specific food or level of irradiation. (P.C.H.)

**32005** (NP-12065) REPORT OF OBSERVATIONS [ON] METABOLISM AND NUTRITION: SUBTASK, RADIATION AND STERILIZATION OF FOODS FOR WISCONSIN ALUMNI RESEARCH FOUNDATION, MADISON, WISCONSIN. M. A. Ross (Armed Forces Inst. of Pathology, Washington, D. C.). Mar. 15, 1962. 33p.

Histologic review was made of 99 Sprague-Dawley rats on long term feeding of potatoes irradiated at 7500-8500 and 15000 to 17000 rad. Statistical evaluation of the observations is reported. Material was received from the higher level (referred to as 2X) as well as from control animals (referred to as 0X). No material from the low level of irradiation was received. The only significant findings, other than sex differences, pertained to the predominance of 2X animals with congestion or edema of the spleen and minor lesions of an occasional granuloma, hemosiderosis or hyperplasia in the mesenteric lymph nodes. Lesions in the liver were associated with 2X females as compared to 0X females; there were minor changes of mild to moderate degrees of fatty metamorphosis, hydropic changes, slight mononuclear infiltrates, congestion, edema or hematopoiesis. The outstanding feature was the relative absence of pneumonic processes and of arteritis. It was concluded that the ingestion of irradiated potatoes by rats, under the conditions described, produced little data suggesting that irradiated potatoes were of etiologic significance. (auth)

**32006** (NP-12066) DOG FEEDING STUDIES—REPORT OF OBSERVATIONS [ON] METABOLISM AND NUTRITION: SUBTASK, RADIATION AND STERILIZATION OF FOODS FOR UNIVERSITY OF MIAMI, SCHOOL OF MEDICINE, CORAL GABLES, FLORIDA. W. E. Tucker, Jr. (Armed Forces Inst. of Pathology, Washington, D. C.). Mar. 15, 1962. 3p.

The effects of diets of either irradiated evaporated milk or beef stew on dogs were studied. It was concluded that the consumption of irradiated evaporated milk or beef stew produced no histopathologic change in dogs that could be attributed to the specific food or level of irradiation. (P.C.H.)

**32007** (NYO-10142) RESEARCH ON APPLICATIONS OF KRYPTON 85. Quarterly Progress Report No. 2, January 1, 1962–March 31, 1962. W. G. Marancik and P. S. Minetti (Air Reduction Co., Inc. Central Research Labs., Murray Hill, N. J.). Contract AT(30-1)-2906. 25p.

Studies were carried out to exploit the unique properties of $Kr^{85}$. Vapor phase polymerizations of acetylene and chlorotrifluoroethylene with $Kr^{85}$ were continued. Experiments for the graft polymerization of chlorotrifluoroethylene or acetylene to natural rubber, using $Kr^{85}$, were initiated. Preliminary development of a self-luminous lamp utilizing $Kr^{85}$ dissolved in polystyrene containing a scintillator was begun. The development of a theoretical basis for the stimulated emission of gamma rays, as well as theoretical consideration of optical masers pumped by nuclear radiation was completed. (auth)

**32008** (ORO-487) THE USE OF BACKSCATTERED GAMMA RAYS FOR EVALUATING DEFECTS IN LOGS AND TREES. Final Report. Ralph L. Ely, Jr. and Wesley E. Loos (Research Triangle Inst., Durham, N. C. Isotope Development Lab.). July 31, 1962. Contract AT(40-1)-2513. 29p. (RTI-2513-T1)

Gamma-ray backscattering was compared with gamma-ray transmission as a means of detecting interior defects in logs, trees, and utility poles. The energy of a scattered gamma ray is determined solely by its initial energy and the scattering angle; it is independent of the scattering medium. This makes it possible to use pulse height selection of the backscattered gamma rays to achieve maximum sensitivity. The optimum geometry conditions were found to be obtained when the source and detector were as close as shielding would permit, and the source and detector were flush with the surface of the wood. It was concluded that while the gamma-ray backscatter method can be used for detecting internal rot in utility poles, gamma-ray transmission measurements are, in general, more sensitive. The backscattering technique is of value when only one side of a surface is accessible or when the defect is near the surface in a thick log or timber. (auth)

**32009** IONIZATION CHARACTERISTICS OF COLD CATHODE RELAY TUBES WITH RADIOISOTOPES. Shiro Otani and Ren Takahashi (Nippon Electric Co., [Japan]). Radioisotopes (Tokyo), 11: 1-8(Feb. 1962). (In Japanese)

The effects of radioisotopes on the ionization time of trigger gaps in Type-CR-13 relay tubes were measured. A mathematical formula is presented for use in circuit design that neglects the holding effect of the tubes. (C.H.)

**32010** GENETIC VARIATION IN GRAIN-SIZE OF RICE. II. TREATMENT WITH PILE RADIATIONS. Hikoyuki Yamaguchi (Tokyo Univ.). Radioisotopes (Tokyo), 11: 33-8 (Feb. 1962). (In Japanese)

**32011** POLAROGRAPHIC STUDIES ON STORAGE OF MEATS. PART XVIII. INFLUENCE OF GAMMA-RAY IRRADIATION ON TWO FRACTIONS OF ACTIN AND MYOSIN SEPARATED FROM BEEF. Tetsujiro Obara, Yasokichi Ogasawara, and Masao Kusama (Tokyo Univ. of Education, Japan). Radioisotopes (Tokyo), 11: 46-57(Feb. 1962). (In Japanese)

Polarographic measurements were made of water extracts of protein from irradiated beef immediately after exposure and after storage at 20°C. Results indicate a synergistic effect of $\gamma$ radiation and cold storage on water extracts. No remarkable changes were observed in NaCl extracts from irradiated beef after cold storage. Actin and myosin solutions from beef were irradiated and changes in the protein waves during storage at 15°C were examined. A pronounced change was observed in the irradiated actin fractions after cold storage. No changes were observed in myosin fractions or in actin fractions immediately after irradiation. It is concluded that the change in shape of the protein wave of the water extract from irradiated beef after storage was due to changes in structure of the proteins in the actin fraction. (C.H.)

**32012** STUDIES ON THE PRESERVATION OF FOODS AND THE CHANGES OF THEIR NUTRIENT COMPONENTS BY GAMMA-RAY IRRADIATION. I. EFFECT ON SOME FRUITS. Seiko Okanoue (Hiroshima Univ.), Matue Fukutani, Mizuho Sugihara, and Isao Hashida. Radioisotopes (Tokyo), 11: 58-67(Feb. 1962). (In Japanese)

Results are reported from studies on the effects of radiation processing on the storage life and nutrient properties of tomatoes, peaches, oranges, and tangerines. Irradiation at doses of about $0.5 \times 10^4$ r $Co^{60}$ $\gamma$ radiation gave best results for thin-skinned fruits and doses of about $1 \times 10^4$ r gave best results for oranges. Irradiation with small doses followed by refrigeration gave best results for all fruits. Irradiation in polyethylene bags, in nitrogen atmosphere,

and at higher radiation doses were detrimental to storage life and nutritive values. (C.H.)

**32013** STUDIES ON THE PRESERVATION OF FOODS AND THE CHANGES OF THEIR NUTRIENT COMPONENTS BY GAMMA-RAY IRRADIATION. II. EFFECT ON SUMMER ORANGE. Seiko Okanoue (Hiroshima Univ.), Matue Fukutani, Mizuho Sugihara, and Isao Hashida. Radioisotopes (Tokyo), 11: 68-80(Feb. 1962). (In Japanese)

**32014** RECENT DEVELOPMENT IN RADIOISOTOPE NON-DESTRUCTIVE TESTING. J. F. Hauck (Lockheed Nuclear Products, Atlanta). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 8p. $0.50.

Radioisotope uses reviewed include research in product development and improvement, nondestructive testing, auxiliary power sources, tracer techniques for analysis and in-process control, and tracer techniques for mapping and cataloging water resources. (A.G.W.)

# ISOTOPE SEPARATION

*Refer also to abstract 31777.*

**32015** (IA-759) THE THEORY OF A REAL ISOTOPE ENRICHING CASCADE. A. Apelblat and Y. Ilamed-Lehrer (Israel. Atomic Energy Commission, Tel Aviv). July 1962. 49p.

The theory of a real (mixing) cascade working with constant cut numbers, with and without losses, is developed. The steady-state distribution of the isotope concentrations in every stage, the value function, the form factor and the number of stages for a desired enriched product in the low concentration range are calculated. The results of the calculations for this real cascade are compared with the corresponding results of the ideal cascade. In the design of a real cascade the concept of a "quasi-ideal" cascade, corresponding to that of an ideal one, is introduced. (auth)

**32016** ENRICHMENT OF HEAVY WATER BY HIGH-PRESSURE EXCHANGE BETWEEN HYDROGEN AND AN AQUEOUS CATALYST SUSPENSION. PART II. CONSTRUCTION AND OPERATION OF A PILOT PLANT. S. Walter, E. Nitschke, C. Bode (Friedrich Uhde GmbH, Dortmund, Ger.), E. W. Becker, R. P. Huebener, R. W. Kessler, and U. Schindewolf. Chem.-Ing.-Tech., 34: 7-10(1962). (KFK-90) (In German)

The construction and operation of a pilot plant for heavy water production by high pressure exchange between hydrogen and an aqueous catalyst suspension was described. Research operation lasting over 86 days proved the engineering feasibility of the method and the validity of the assumption used in an earlier estimation of the industrial efficiency. (tr-auth)

**32017** ENRICHMENT OF HEAVY WATER BY HIGH-PRESSURE EXCHANGE BETWEEN HYDROGEN AND AN AQUEOUS CATALYST SUSPENSION. PART III. EFFECTS ON SPECIFIC EXCHANGE PERFORMANCE OF ADDITIVES. E. W. Becker, R. W. Kessler, and R. P. Huebener (Technische Hochschule, Ger.). Chem.-Ing.-Tech., 34: 105-8(1962). (KFK-92) (In German)

The industrial efficiency of high pressure exchange between hydrogen and an aqueous catalyst suspension was determined chiefly through the costs of the high pressure column and the catalyst. A study was made to determine whether an improvement of the specific exchange capacity could be attained by additives to the liquid or gaseous phases. Then the negative effects which impurities introduced accidentally in the technical operation could have on the specific exchange capacity were investigated. (tr-auth)

**32018** THE ISOTOPIC EXCHANGE BETWEEN GASEOUS HYDROGEN AND LIQUID AMMONIA. PART 1: THE KINETICS OF THE EXCHANGE IN A BUBBLING CONTACTOR. P. L. Rebora (L.R.S.R., Milan). Energia nucleare (Milan), 9: 388-96(July 1962). (In English)

The kinetics of the exchange between hydrogen and liquid ammonia in the presence of potassium amide were examined in view of the application of this process to the large scale production of heavy water. Tests were run in a bubbling apparatus at pressures ranging from 60 to 250 atm and temperatures from −50 to +40°C. The kinetics of the exchange were determined as a function of temperature, pressure, potassium amide concentration, diameter of the holes in the gas distributor, and gas velocity. The effect of dilution of hydrogen with nitrogen (in the same ratio as in the ammonia synthesis mixture) was also investigated. (auth)

**32019** OPTIMIZATION OF THE SQUARED OFF CASCADE AS APPLIED TO DISTILLATION. Dipak Gupta and S. N. Ray (Atomic Energy Establishment, Trombay, India). Ind. Eng. Chem., Process Design Develop., 1: 255-62(Oct. 1962).

Some generalized relations were developed with all the necessary cost factors for the design of a distillation plant for the separation of stable isotopes based on the principles of the squared off cascade. These relations, useful for design of a plant for enrichment of an isotope in concentration ranges up to about 5%, were used to design a water distillation plant for the enrichment of heavy water. (auth)

**32020** ISOTOPIC FRACTIONATION OF BORON IN THE LOW-TEMPERATURE EXCHANGE SYSTEM. II. ON THE COORDINATION COMPOUNDS OF BORON TRIFLUORIDE WITH SULFUR DIOXIDE, METHYL CHLORIDE AND MONOCHLORODIFLUOROMETHANE. Ryohei Nakane and Osamu Kurihara. Sci. Papers Inst. Phys. Chem. Research (Tokyo), 56: 161-3(June 1962). (In English)

Isotopic separation factors for $BF_3$–$SO_2$ system for separation of boron isotopes at −96.5°C (mp of cumene) are determined by a new type gas-liquid contactor, obtaining a value at 1.022, when the mole ratio of $SO_2$ to $BF_3$ in the liquid is larger than 1, and the results given in a previous paper are corrected. Moreover, the separation factors for $BF_3$–$CHClF_2$ and $BF_3$–$CH_3Cl$ system at −96.5 and −112°C (mp of $CS_2$) are determined, and the highest values obtained at the latter temperature are 1.017 and 1.021. Thus, it is found that $BF_3$ can also form a complex with $CH_3Cl$ or $CHClF_2$, and the stability of the complexes decreases in the following order: $BF_3 \cdot SO_2 > BF_3 \cdot CH_3Cl > BF_3 \cdot CHClF_2$. (auth)

**32021** ISOTOPIC FRACTIONATION OF NITROGEN AND OXYGEN IN THE LOW-TEMPERATURE EXCHANGE SYSTEM. ON THE COORDINATION COMPOUNDS OF NITRIC OXIDE WITH HYDROGEN CHLORIDE. Ryohei Nakane and Shohei Isomura. Sci. Papers Inst. Phys. Chem. Research (Tokyo), 56: 164-6(June 1962). (In English)

It was found that at a temperature from −140 to −160°C the mixture of NO, HCl, and $CHClF_2$ forms a stable and dense purple colored solution, and thereby a molecular complex, NO · HCl, may exist in the liquid phase, which has been approved by measuring the single-stage separation factor isotopic exchange between NO gas and NO in the solution at −160°C. Its highest value obtained is 1.040 for nitrogen and 1.060 for oxygen isotopes, with $N^{15}$ and $O^{18}$ concentrated in the liquid phase. (auth)

**32022** SEPARATION NOZZLE DISSOCIATION IN DEFLECTED GAS JETS. E. W. Becker, H. Burghoff, and J. Gspann (Technische Hochschule, Karlsruhe, Ger.). Z. Naturforsch., 16a: 955-60(Oct. 1961). (KFK-78) (In German)

In the separation nozzle effect there exists a relationship between the deflection of the flow lines of the supersonic beam and the dissociation. In the free expansion of a given gas, the deflection of the flow lines can be affected only by the expansion behavior. Since the possible expansion behavior is limited in a practical utilization of the method on economic grounds, the effect of a mechanical deflection of the jet in the space between the nozzle and the separation plate on the spatial behavior of the dissociation and on the specific expenditures was investigated. (tr-auth)

# MATHEMATICS AND COMPUTERS

*Refer also to abstracts 31673 and 32536.*

**32023** (LADC-5173) THE COLASL AUTOMATIC CODING LANGUAGE. Karl G. Balke and Glenn L. Carter (Los Alamos Scientific Lab., N. Mex.). Feb. 19, 1962. Contract [W-7405-eng-36]. 70p.

Development and functions of the COLASL system are described. This system is used to generate codes for the IBM-7030 (STRETCH) computer. Included are details of the input hardware and a description of the COLASL language. A sketch concerning features of the COLASL translator is also included. (J.R.D.)

**32024** (NAA-SR-Memo-7419) CODE FOR COMPUTING EXCESS PRESSURE DUE TO "WATER HAMMER." Douglas Logan (Atomics International, Div. of North American Aviation, Inc., Canoga Park, Calif.). June 13, 1962. Contract [AT-11-1-GEN-8]. 12p.

A digital code designed to determine excess pressure caused by "water hammer", is described. The basic theory is presented and the equations that are solved by the code, are shown. The preparation of input data for the program is described in detail. A card-by-card listing of all the input variables is included along with a sample problem input on FORTRAN Data Sheets. A complete description of the output information is also presented. The method of hand calculation of excess pressure caused by "water hammer" for "instantaneous" blockage of liquid is described. (auth)

**32025** (ORNL-TM-307) TWO AUXILIARY CODES FOR USE WITH RENUPAK. D. K. Trubey (Oak Ridge National Lab., Tenn.). Aug. 10, 1962. Contract [W-7405-eng-26]. 5p.

Two IBM-7090 codes were written to aid the user of the neutron moments method code RENUPAK. One code computes and punches response function input cards for RENUPAK or NIOBE (another neutron transport code). The second code reads RENUPAK flux tapes and prints out a compact edit including dose rate as a function of distance. (auth)

**32026** (ORNL-TM-333) AN IBM 7090 FORTRAN PROGRAM FOR ASME UNFIRED PRESSURE VESSEL DESIGN AND PRELIMINARY COST ESTIMATION. C. E. Prince and R. P. Milford (Oak Ridge National Lab., Tenn.). Oct. 17, 1962. Contract [W-7405-eng-26]. 40p.

An IBM 7090 FORTRAN program was written for the preliminary design and cost estimation of unfired pressure vessels with or without a jacket. Both vessel and jacket designs conform to the 1959 ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels. Vessels and jackets from 5 in. pipe through 84 in. o.d. and $\frac{1}{4}$ in. through $1\frac{1}{2}$ in. in metal thickness may be designed by this program as written. Total vessel cost is the sum of metal and fabrication costs, each on a weight basis. (auth)

**32027** (ORNL-TM-345) ZØRCH—AN IBM 7090 PROGRAM FOR THE ANALYSIS OF SIMULATED MSRE POWER TRANSIENTS WITH A SIMPLIFIED SPACE-DEPENDENT KINETICS MODEL. C. W. Nestor, Jr. (Oak Ridge National Lab., Tenn.). Sept. 18, 1962. Contract [W-7405-eng-26]. 27p.

A program (ZØRCH) is described which is an extended and revised version of the point-model kinetics program MURGATRØYD. A model is used in which the axial space dependence of the fuel and graphite temperatures is calculated, and the effect on reactivity of deviations from the steady state values is assumed to be given by the product of an appropriate temperature coefficient of reactivity times the deviations from the steady state value of the nuclear average temperature (NAT). The NAT is computed using a "sine-squared" weighting function in the axial direction and using an input weighting factor in the radial direction. The shape of the power density is taken to be time-independent in contrast to the shapes of the temperature distributions, which are time-dependent in the calculation. This program is intended to be used in surveys of reactor behavior under a wide range of conditions. It is therefore based on a simplified model in order to reduce computing time, but should provide a better approximation to reactor behavior than does a purely space-independent calculation. A derivation of the equations used in the program, instructions for its use, and sample input and output for a test case are included. A FØRTRAN source deck and a binary object deck are on file. (auth)

**32028** (ORNL-TM-361) DEVELOPMENT OF A GENERAL METHOD OF EXPLICIT SOLUTION TO THE NUCLIDE CHAIN EQUATIONS FOR DIGITAL MACHINE CALCULATIONS (thesis). D. R. Vondy (Oak Ridge National Lab., Tenn.). Oct. 17, 1962. Contract W-7405-eng-26. 92p.

A procedure was developed for digital machine calculation of nuclide concentration behavior with time. This involved an explicit solution to the nuclide chain equations in a form most suitable for calculation with a limited number of significant figures. The procedure was programmed for the IBM-7090 with provision made for interlocking chains; limitations were examined by solution of a number of example problems. Study of the results indicated that the calculation is practical for application to reactor depletion problems and to other problems which can be represented by the equations. (auth)

**32029** (TID-16679) THE DEVELOPMENT OF A FORTRAN PROGRAM FOR COMPUTING U-235 SCHEDULES FROM ASSUMED REACTOR PARAMETERS. Edwin H. Davidson (Division of Operations Analysis and Forecasting, AEC). Aug. 1962. 42p. (OA:R-27)

One of the FORTRAN (formula translation) programs used in AEC Headquarters for forecasting the flow of enriched U to and from the gaseous diffusion plant in support of nuclear power reactors is discussed. (auth)

**32030** REPRESENTATION OF NON-LINEAR SYSTEMS ON ANALOG COMPUTERS. APPLICATION TO NON-LINEAR AMPLIFIERS AND TO NUCLEAR REACTORS. Henri B. Smets. p.486-93 of "Actes des Secondes Journees Internationales du Cal cul Analogique, Strasbourg, 1958." Brussels, Presses Academiques Europeennes, 1958. (In French)

The problem of the representation of nonlinear systems on the analog computer was studied by functional analysis. The Duhanel relation of linear systems was generalized to nonlinear systems, and it was proved that all nonlinear systems can be completely analyzed by a study of the pulse response. The synthesis on the calculator is made by means of linear systems, power amplifiers, and multiple multipliers. The complexity of the study depends on the form and number of characteristic nuclei of the representation. The most simple nonlinear systems can be analyzed by means of the single index signal and can be synthesized by means of linear systems and power amplifiers. (tr-auth)

# METALS, CERAMICS, AND OTHER MATERIALS

## General and Miscellaneous

*Refer also to abstracts 31375, 31764, 31765, 31769, 31770, and 32541.*

**32031** (BMI-X-207) PROGRESS ON USAEC/AECL COOPERATIVE PROGRAM QUARTERLY REPORT FOR PERIOD JUNE–AUGUST 1962. Stanley W. Porembka (Battelle Memorial Inst., Columbus, Ohio). Sept. 13, 1962. Contract W-7405-eng-92. 10p.

Activities in a program to determine long-term creep-rupture properties of selected SAP alloys are reported. The program is in support of heavy-water-moderated and organic-cooled reactors. The temperatures of interest are 700, 800, and 900°F. Preliminary tests of 1 to 1000 hr are conducted at each test temperature. These data are then used to estimate stresses for the 10,000 to 100,000 hr tests. Data obtained during the period are included. (J.R.D.)

**32032** (CEND-152) THE DEVELOPMENT AND TESTING OF $UO_2$ FUEL SYSTEMS FOR WATER REACTOR APPLICATIONS. Quarterly Report No. 2, October–December 1961. B. E. Murtha and W. P. Chernock (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.). Jan. 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT (30-1)-2863. 65p. (EURAEC-259)

Experiments have shown that a variety of particle size distributions can be compacted in rods of short length to about 93% of theoretical density with sufficient compaction time. The resulting particle size distributions are similar in all cases, and the time required for compaction increases proportionately to the amount of pulverization required. Current experiments have demonstrated that tubes up to six feet in length can be loaded and densified to the 80-90% of theoretical density range on very small and inexpensive vibrators. Fuel rods loaded by the above technique to 80 and 85% of theoretical density and reduced in cross section by one swaging pass have a final gross density of 92-93% of theoretical density and a local density variation of only ±0.9% of theoretical density. Both hot and cold collapse testing is under way on annealed and work-hardened type 347 stainless steel cladding materials. The data compare favorably with predictions based on theoretical tube collapse considerations. Experiments are continuing to better define the transition region between elastic and inelastic collapse criteria. Tests on thin walled (fuel supported) tubing specimens were performed to study the nature of collapse in the region of chipped or axially separated pellets, low density powders, and fuel to clad clearances. (auth)

**32033** (DP-753) A REMOTELY OPERABLE CATHODIC VACUUM ETCHER. Richard D. Kelsch (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). Aug. 1962. Contract AT(07-2)-1. 10p.

A cathodic vacuum etcher unit was developed for etching irradiated U and U alloys in a hot cell. The etching chamber, vacuum pump, and vacuum controls are located in a hot cell and can be remotely installed and maintained. All in-cell operations are performed with master-slave manipulators. (auth)

**32034** (GEMP-15A) HIGH-TEMPERATURE MATERIALS PROGRAM PROGRESS REPORT NO. 15, PART A. (General Electric Co. Flight Propulsion Lab. Dept., Cincinnati). Sept. 14, 1962. Contract AT(40-1)-2847. 73p.

Activities in a program to produce and evaluate fuel element materials capable of long time service in oxidizing atmospheres at high temperatures (>1000°C) with negligible fission fragment release are reported. An investigation of the possible reaction between Y and $UO_2$ was made using die specimens of Fe–30Cr–1Y (Al free). At 1300°C reactions occurred for stoichiometric $UO_2$ and to a less extent for $O_2$-excess $UO_{2.1}$. Evidently Y reduces $UO_2$ as well as $Al_2O_3$. As an alternate fuel material, investigation of US was started. Satisfactory US was prepared by reducing $US_2$ with U metal at 2000°C in $H_2$. This material was stable at 2200°C in $H_2$ and showed no reaction with a W crucible. Capsules of Pd loaded with Pd–60$U_3O_8$ (volume %) reacted at 1200°C in a manner similar to capsules loaded with $UO_2$. Rupture of the Pd cladding occurred in less than 400 hours, apparently as a result of fuel expansion. The addition of Rh (up to 24 wt %) to Pd does not reduce appreciably the evaporation rate of Pd at 1400°C in flowing air. Oxidation rate measurements were obtained for Ir to 2000°C and for Rh to 1800°C at two levels of airflow. The data are in good agreement with data reported for lower temperature studies. The reliability of the W resistance furnace, designed for air testing, has been proven up to 2000°C for 100 hours. Details of a program to develop and evaluate methods of preparing and joining refractory metals and alloys, and other high temperature materials for use as fueled and non-fueled, high temperature (1000 to 3000°C) reactor components are given. Stress-rupture data for Re sheet material at 2600 and 2800°C and Ta–10W sheet at 2800°C are presented for testing times up to 10 hours. Of the refractory metals and alloys tested thus far, Re is the strongest at high temperatures. At 2800°C, its rupture strength is approximately equal to that of the second best alloy, W–26Re, at 2600°C. Stress-rupture testing of Re electron beam welds was initiated. The time-temperature-pressure relationships were established for solid-state diffusion bonding of refractory metals and alloys. Several honeycomb structures were fabricated to demonstrate the usefulness of this joining technique. Stress-rupture data obtained from tests conducted at 2600°C on diffusion-bonded lap joints of Ta, Ta–10W, and Mo–50Re compare favorably with the results obtained from the electron-beam-welded specimens. Stress-rupture testing was initiated to determine the influence of atmosphere, i.e., Ar and $H_2$, on the rupture strength of Mo. Rupture strength of Mo increased and ductility decreased in an Ar atmosphere compared with a $H_2$ atmosphere. Further tests are necessary to explain this phenomenon. A study was initiated to develop new braze alloys for use with refractory metals components. Other work is reported in a program to determine the effect of radiation on the time-, temperature-, and stress-dependent properties of selected high-temperature alloys and refractory metals, to identify the causes of any observed reductions in these properties, and to develop remedial measures. Stress rupture testing of specimens for determination of the threshold of neutron-irradiation-induced damage is nearly complete. The threshold of neutron-induced reduction in the 50-hr rupture life of specimens, irradiated and tested at 650°C, appears to be lower for A-286 than for Hastelloy X. The threshold for A-286 is less than $10^{18}$ nvt ($E_n \geq 1$ Mev) while the threshold for Hastelloy X appears to be greater than $10^{18}$ nvt ($E_n \geq$

1 Mev). Detailed structure studies were continued on A-286, and preliminary observations made on Hastelloy X. Analysis of A-286 residues obtained by electrolytic digestion continues to show the presence of an unidentified phase. Optical studies of fracture areas of irradiated and unirradiated specimens indicate probable differences in the length of secondary cracks in A-286. Comparisons of control data and irradiated A-286 tensile specimen data indicate that neutron irradiation at 540 and 650°C does not appreciably change either the tensile or the yield strength of A-286, although the 10-hr rupture strength at 540 and 650°C is reduced by 7 to 24% by irradiation in the same temperature range. The atom displacement production by primary knock-on atoms with energies greater than the ionization threshold energies was found by theoretical calculations to be enhanced in finite specimen samples relative to the displacement in semi-infinite systems. The enhancement is relatively large in the case of isotropic neutron scattering in the sample. Work toward establishing the stability of 80Ni–20Cr fuel ribbon at elevated temperatures in air when subjected to neutron irradiation for long periods of time corresponding to burn-up levels of 25% of the $U^{235}$ atoms present is also discussed. The irradiation test, designated ORF-2, was under way in the F-2 facility of the ORR since April 16, 1962. Use of the F-2 facility has alternated between this and other GE-NMPO experiments, necessitating occasional removal of capsule ORF-2 from the pile and storing it in the pool. The capsule contains a 0.9 by 0.4 in. segment of 0.020-in.-thick 80Ni–20Cr clad fuel sheet. Nominal specimen temperature was 815°C, and the specimen was exposed to air passing over one cladding surface. (auth)

**32035** (JEN-102-DMe/I-9) NUEVAS APORTACIONES AL METODO DE VAN ARKEL PARA LA PURIFICACION DE METALES SOBRE FILAMENTOS INCANDESCENTES. (New Contribution to the Method of Van Arkel for the Purification of Metals on Incandescent Filaments). Manuel Lopez Rodriguez and J. Terraza Martorell (Spain. Junta de Energia Nuclear, Madrid). 1962. 80p.

Thesis submitted by Manuel Lopez Rodriguez to Univ. of Madrid.

The purification of zirconium in a cyclical static process using $ZrI_4$ as the volatile compound and W filaments was studied after a review of previous works on the subject. The equations corresponding to the isothermal processes are given, and the experimental method is described in some detail. The optimum conditions of temperature and velocity for the maximum purification of the metal were determined. (J.S.R.)

**32036** (NAA-SR-Memo-7538) UC FUEL FABRICATION IN EXISTING FEM EQUIPMENT. N. Ketzlach (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). July 6, 1962. Contract [AT (11-1)-GEN-8]. 7p.

A request was made to establish nuclear safety criteria for the fabrication of UC fuel elements using existing FEM equipment. A similar study was based on the use of the smaller equipment in the FED area. Safe handling and storage criteria for the 3.7% $U^{235}$ enriched fuel rods of 0.892-in. dia. are presented. The existing Lazy Susan Retort may be used for the rod assembly provided the rods occupy a single annular ring in this retort. The rods, should be packaged, 16 per box, according to the criteria given. Under these conditions it is safe to transfer the total required number of rods (64) in a single shipment. (auth)

**32037** (ORNL-TM-309) PREPARATION OF STOICHIOMETRIC URANIUM MONOCARBIDE CYLINDERS. D. T. Bourgette (Oak Ridge National Lab., Tenn.). Oct. 4, 1962. Contract [W-7405-eng-26]. 27p.

Employing a modified arc-melting technique, homogeneous cylinders of stoichiometric UC were consistently produced. The cylinders ranged in size from 0.25-in. dia. by 1 in. long to 0.375-in. dia. by 3 in. long. The top 10% of nearly all cylinders did, however, contain shrinkage voids that could not be eliminated. UC buttons previously prepared by arc melting the elements were placed over a graphite-mold cavity, but in contact with Cu in an Ar-atmosphere arc furnace. When the UC charge became fully molten, it dropped into the cavity and solidified instantaneously. The measured densities of the arc-cast cylinders were 99.8% of theoretical with compositional limits of ±30 ppm C. The study was initiated because of a need for pure stoichiometric UC radiation specimens and a need for nonstoichiometric specimens containing controlled C concentrations. Therefore, emphasis was placed on purity control of the starting material and furnace atmosphere, rate of power consumption, accuracy of weighing procedures, and arc-melting procedures. Variations in either of these preparational steps would result in an undesirable product. (auth)

**32038** (ORNL-TM-334) CALCULATION OF THE REQUIREMENTS FOR OPERATION OF REFRACTORY-METAL COMPONENTS AT HIGH TEMPERATURE IN VACUUM. R. E. Clausing (Oak Ridge National Lab., Tenn.). Sept. 18, 1962. Contract W-7405-eng-26. 15p.

Equations based on kinetic theory relate the contamination of refractory metals in vacuum to the appropriate variables. Several examples are given for which the allowable system pressures are calculated. The examples illustrate the effect of varying several parameters. The importance of the sticking factor for active gases on hot refractory metals and its effect on the system design are discussed. The data for estimating the sticking factor for $O_2$ on Nb are given, along with some estimated values. Experimental data on the composition and rates of outgassing of ultrahigh-vacuum systems and their importance in system design are discussed. Several methods of reducing contamination rates and the relative ease and effectiveness of these methods are presented. It was concluded that tests of 1000 hr or longer will probably require system pressures of between $10^{-9}$ and $10^{-6}$ torr, the particular pressure depending upon the residual gas composition, test duration, allowable contamination level, and the other variables discussed. Since the most important source of contamination in a properly designed ultrahigh-vacuum system is the outgassing process, bakeable systems should be designed to operate with walls as cool as practical, and to have a minimum of surface area and outgassing materials inside. Considerable added protection may be obtained by incorporating sacrificial getter surfaces in the system, or, alternatively, higher pressures may be tolerated if proper getter design is used. (auth)

**32039** (PWA-1863) MEASUREMENT OF SPECTRAL AND TOTAL EMITTANCE OF MATERIALS AND SURFACES UNDER SIMULATED SPACE CONDITIONS, JULY 1, 1959–JUNE 30, 1960. (Pratt and Whitney Aircraft Div., United Aircraft Corp., Hartford, Conn.). Contract NASW-104. 298p.

The first phase of an engineering program to measure thermal radiation characteristics of metal and coated metal surfaces under conditions of interest in space-craft applications was completed. Both spectral and total emittance measurements were made at 200 to 2000°F and at indicated pressures as low as $4 \times 10^{-9}$ mm Hg. The change of emittance resulting from operation at elevated temperatures

and high vacuum over periods of time up to 550 hours was also determined for some of the more promising materials. Total hemispherical emittance values above 0.7 were found for several coating materials in the temperature range of interest for application to the radiator-condensers of space-craft Rankine-cycle powerplants with liquid-metal working fluids. Coating materials which appear promising for this application include Cr black, Nb oxide, acetylene black, CuO, $ZrO_2$, BC, and crystalline B. Total emittance was determined for two smooth metal surfaces, one sand-blasted metal surface, and sixteen coating materials. Spectral emittance was determined for three coatings and three smooth metal surfaces. The change of emittance with time under elevated temperature and high vacuum conditions was also determined for four of the coating materials and for the sandblasted metal surface. Total hemispherical emittance was determined by comparing the electrical power dissipation per unit area in a heated strip or tube specimen to the black body emissive power corresponding to measured specimen temperature. Spectral normal emittance was determined by comparing the spectral intensity issuing normal from the surface of an electrically heated specimen tube to the spectral intensity at the same wavelength of the essentially black body radiation at specimen temperature issuing from the tube interior through a small hole in the tube wall. Intensity ratios were obtained using a dual beam spectrophotometer viewing the specimen tube through a NaCl window in the vacuum chamber wall. Measurements were made over the wavelength range of 0.45 to 13.0 microns. Pt–90% Pt–10% Rh thermocouples, chromel-alumel thermocouples, and an optical pyrometer were used to measure specimen temperature. Several investigations were made to permit estimation of the accuracy of the emittance measurements. Errors caused by reflections from the chamber walls, local perturbations of specimen temperature, and heat conduction from the ends of the specimen were studied in regard to both total and spectral measurements. Effects of scattered radiation and imperfection of the "black body hole" radiation were also examined with reference to spectral measurements, as were thermocouple calibration drift problems associated with the total measurements. On the basis of these investigations it is believed that spectral emittances as reported are within +3% to –5% of the correct values, total emittances are within ±3% as measured on the spectral rig, and within ±5% as measured on the total emittance rig. (auth)

**32040** PURIFICATION OF TANTALUM AND NIOBIUM. G. L. Miller. Ind. Chemist, 38: 406-10(Aug. 1962).

The removal of metallic and non-metallic impurities from Ta and Nb by sintering and arc melting is reviewed. The degree of purification obtainable and the limitations of each method are discussed. (D.L.C.)

**32041** SINTERED ALUMINUM PRODUCTS FOR REACTOR APPLICATION. Niels Hansen. Ingeniøren, 5: 52-60(June 1961). (In English)

Preliminary examination on sintered aluminum product (SAP) alloys for reactor application was carried out by the Metallurgical Laboratory of the AEK. The mechanical properties of SAP at elevated temperatures are only slightly altered by prolonged heating. Its structural stability is shown to be affected by heat treatment at 400°C and above. Blistering starts at about 610°C, and fissures appear in unstressed material at 500°C, and in stressed material at 400°C after extended periods of heating. The tendency to blister and fissure formation can be removed from the material by vacuum heat treatment at about 600°C. SAP shows good chemical compatibility with polyphenyls at 400°C and uranium dioxide at 550°C when tested for extended periods. SAP may be formed by extrusion, pressing, rolling, and swaging. Thin-walled tubes with twisted fins have been made. Joining of SAP parts by flash and by braze welding is satisfactory. End closures of the tubes are vacuum-tight and show a mechanical strength equivalent to the parent material. Neutron irradiation of SAP carried out by other laboratories shows little or no effect on its mechanical properties. (auth)

**32042** ELECTRODEPOSITION OF THORIUM FROM FUSED SALTS INTO A MOLTEN ZINC CATHODE. Ralph E. Johnson (Atomics International, Canoga Park, Calif.). J. Electrochem. Soc., 109: 989-91(Oct. 1962).

A technique was developed for the electrodeposition of Th from a fused LiCl–KCl–$ThCl_4$ bath with a molten Zn cathode and Th anode in which ~100% current efficiencies are obtained at both electrodes. The most important condition in the process is the stirring of the Zn, and ~15% of Th in Zn can be obtained readily. The optimum $ThCl_4$ concentration in the bath is 15%, and current efficiencies are independent of current densities. (D.L.C.)

**32043** ELECTRODEPOSITION OF INDIUM ON GERMANIUM. V. M. Kochegarov, D. I. Zaks, and V. D. Samuilenkova (Taganrog Radiotechnical Inst., USSR). Pribory i Tekh. Ekspt., No. 3, 187-9(May-June 1962). (In Russian)

Electrolytic deposition of indium on germanium was developed. The method and the deposit on an n-Ge crystal are described. (R.V.J.)

**32044** THERMAL ETCHING OF SINTERED $UO_2$. B. M. Gibbs and H. Rawson (A.E.I. Research Lab., Rugby, Eng.). Trans. Brit. Ceram. Soc., 60: 854-7(Nov. 1961).

With $UO_2$, non-oxidizing atmospheres have to be used. Experiments were carried out in purified argon and in purified hydrogen. (auth)

**32045** NOTIONS ON THERMODYNAMICS AND KINETICS UNDER VACUUM. B. Blanc (Centre d'Etudes Nucléaires, Saclay, France). Vide, 16: 257-8(Sept.-Oct. 1961). (In French)

Thermodynamic and kinetic considerations governing the metallurgical applications of electron-bombardment techniques are outlined. The purification of metals by electron-bombardment methods is discussed; several purification mechanisms are noted, including selective vaporization (e.g., of Fe from Zr), deoxidation by volatilization of an oxide (for cases in which the oxide has a vapor pressure much higher than that of the metal), and deoxidation by C (e.g., by the reaction MeC + MeO ⇌ CO + 2 Me). (T.F.H.)

**32046** THE PURIFICATION OF METALS BY ELECTRON BOMBARDMENT. J. A. Belk (Armament Research and Development Establishment, Fort Halstead, Kent, Eng.) and A. Calverley. Vide, 16: 270-82(Sept.-Oct. 1961). (In French and English)

The application of electron-beam floating-zone-melting methods to the purification of refractory metals is examined. Systems used and results obtained in the zone melting of Mo, Mo–Ta, Mo–W, and Mo–Nb are outlined. The floating-zone methods are compared with other electron-bombardment methods, viz., solid-state outgassing, melting on a cooled hearth, and drip melting. Results obtained with the cooled-hearth method on U and Nb are summarized. (T.F.H.)

**32047** NIOBII I EGO SPLAVY. (Niobium and its Alloys). G. V. Zakharova, I. A. Popov, L. P. Zhorova, and B. V. Fedin. Moscow, Metallurgizdat, 1961. 382p.

A survey is given of the physico-chemical and mechanical properties of Nb and Nb alloys and of preparation methods for Nb powder and compacts. Effects of gases and oxidation processes and mechanical and thermal treat-

ments on Nb and its alloys are discussed. Deformation processes, welding, metallography, and industrial applications are also considered. Extensive bibliographies are included at the end of each chapter. (R.V.J.)

**32048** PRODUCTION OF URANIUM MONOCARBIDE IN CANADA. F. H. Hueston (Eldorado Mining and Refining Co. Ltd., Port Hope, Can.). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 7p. $0.50.

Possible methods of producing UC are reviewed. It is concluded that a development program for production of UC to be set up by Atomic Energy of Canada Ltd. will concentrate on a vacuum skull arc-melting technique using sintered compacts of $UO_2$ and graphite as feed. (A.G.W.)

**32049** RARE EARTH RESEARCH. Proceedings of the Second Conference, September 24-27, 1961, Held at Glenwood Springs, Colorado. Joseph F. Nachman and Charles E. Lundin, eds. New York, Gordon and Breach Science Publishers, 1962. 367p.

Thirty papers are included which discuss the chemical, mechanical, metallurgical, thermodynamic, and physical properties of rare-earth metals, alloys, and compounds. Rare-earth chalcogens, borides, and nitrides are treated. Separate abstracts were prepared for 27 of the papers; the remaining three papers have been previously abstracted in NSA. (D.L.C.)

**32050** THE CALCIUM FLUORIDE–RARE-EARTH OXIDE SYSTEMS IN LABORATORY ATMOSPHERE. K. S. Vorres (Univ. of Miami, Coral Gables, Fla.). p.9-13 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

Mixtures of $CaF_2$ and rare-earth oxides ($La_2O_3$, $CeO_2$, $Pr_6O_{11}$, $Nd_2O_3$, $Sm_2O_3$, $Gd_2O_3$, $Y_2O_3$, and $Yb_2O_3$) were pressed, fired, and examined by x-ray powder diffraction. The weight-loss data for all oxides except $Pr_6O_{11}$ and $Sm_2O_3$ indicated less than 10% hydrolysis after 5 days' heating at 950°C. No reaction was observed for $CeO_2$, $Gd_2O_3$, $Y_2O_3$, and $Yb_2O_3$, but new phases were observed in $La_2O_3$, $Nd_2O_3$, and $Sm_2O_3$. The large weight loss in $Pr_6O_{11}$ suggests reduction. Hydrolysis of $Sm_2O_3$ occurred to an extent of 40% in the 1:1 mixture. Ignition of $CaCO_3$ with the rare-earth oxides did not produce any new phases, and it is concluded that compound formation is necessary for acceleration of the hydrolysis reaction. (D.L.C.)

**32051** COMPARATIVE LIQUID-LIQUID EXTRACTION BEHAVIOR OF EUROPIUM(II) AND EUROPIUM(III). D. F. Peppard, E. P. Horwitz, and G. W. Mason (Argonne National Lab., Ill.). p.15-27 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The liquid-liquid extraction behavior of Eu(II) into solutions of acidic phosphoric and phosphonic esters was investigated both on a macro-scale and tracer-scale. The distribution ratio of Eu(II) was investigated as a function of solvent concentration in the organic phase and HCl concentration in the aqueous phase using $\beta$-active 13, 16-yr europium-152, 154. Advantage was taken of the large separation factors Pm(III) /Eu(II), Sm(III)/Eu(II), and Gd(III)/Eu(II) in effecting the mutual separation of promethium-147 and europium-152, 154, the high purification of promethium-147 with respect to europium-152, 154, and the enrichment, concentration, and recovery in high yield of europium from a rare-earth oxide containing 0.1% Eu. (auth)

**32052** THERMOCHEMISTRY OF EUROPIUM(II) ION. C. T. Stubblefield and M. D. Taylor (Prairie View Agricultural and Mechanical Coll., Texas). p.29-33 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

In strong acid solution Eu(II) is oxidized very slowly to Eu(III) in the absence of oxygen. However, if oxygen is present, a comparatively rapid oxidation occurs. Apparently, two competing reactions take place to varying degrees: (A) oxidation by hydrogen ions and (B) oxidation by oxygen. Complications arise in the attempt to establish the heat of oxidation of Eu(II), unless one or the other of these two paths is blocked. The heat of reaction of $EuCl_2$ with 6.00*M* HCl, in which the oxidation of Eu(II) by hydrogen ions predominated, was found to be $-24 \pm 1$ kcal/mole. The acid was made as oxygen-free as practicable, and platinum black employed as a catalyst. A semi-micro adiabatic calorimeter constructed for determinations of the heats of solution in acid or water of milligram quantities of samples is described. (auth)

**32053** THE INFRARED SPECTRA OF PRASEODYMIUM OXIDE AND PRASEODYMIUM CARBONATE. A. F. Clifford and P. A. Faeth (Purdue Univ., Lafayette, Ind.). p.35-46 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

Several samples of $PrO_x$ were prepared which have x values $1.50 < x < 1.83$; by decomposing $PrO_{1.83}$ *in vacuo* any x value could be prepared. The preparations were analyzed for infrared-absorption activity in the region 2 to 16 microns. An absorption band at about 15 microns appeared for all samples if the specimens were permitted access to the atmosphere. No band appeared in this region if the samples were analyzed immediately after their preparation. Infrared analysis of samples of praseodymium carbonate and praseodymium hydroxide showed absorption acitvity in the same regions where activity was noted for air-exposed praseodymium oxide samples. It is concluded that the absorption band at 15 microns for the air-exposed oxides is due to hydration-carbonation effects. The band is probably indicative of a metal-oxygen bond as proposed by Meloche for oxide systems; the band might also be due to a chemisorbed species ($CO_2$ or $H_2O$). A sample of praseodymium carbonate was decomposed *in vacuo* and the spectrum of the resultant compound was observed. A differential thermal analysis (DTA) of the carbonate in air showed that the dehydration probably is complete below 300°C; the carbonate loses $CO_2$ at 470 and 630° C and is subsequently converted to the oxide $Pr_6O_{11}$ near 400°C. (auth)

**32054** DETERMINATION OF THE RARE-EARTH–HEDTA STABILITY CONSTANTS WITH THE MERCURY ELECTRODE. J. L. Mackey and J. E. Powell (Ames Lab., Ames, Iowa). p.47-58 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962. (IS-304)

The stability constants of the complexes formed between the rare earths and N′-hydroxyethylethylenediamine-N,N,N′-triacetic acid (HEDTA) were determined by the mercury electrode method at a temperature of 20°C and an ionic strength of $\mu = 0.10$. It was necessary to measure the mercury(II) — HEDTA stability constant using the mercury electrode. The results of the rare-earth stability constants are compared with the values determined by other methods. It was found that the mercury electrode gave more reliable absolute values for the rare-earth — HEDTA constants than other methods. In addition the stability constants show a gadolinium break that was not apparent in the constants determined by other methods. (auth)

**32055** SEPARABILITY OF GADOLINIUM, TERBIUM, AND DYSPROSIUM IN AQUEOUS LITHIUM CITRATE ELECTROLYTES WITH AMALGAM CATHODES. E. I. Onstott (Los Alamos Scientific Lab., N. Mex.). p.59-68 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The separability of Gd, Tb, and Dy in lithium citrate

electrolytes was determined under controlled conditions of electrolyte composition and current density at 25°C. Separation factors for Gd/Tb were between 2.38 and 2.64 with the electrolyte ratio of Gd/Tb varied between 1.000 and 9160. Separation factors between 2.66 and 3.14 were measured for Tb/Dy with the Tb/Dy electrolyte ratio varied between 0.000106 and 1.000. A separation factor of 7.4 was measured for Gd/Dy with the electrolyte ratio of Gd/Dy equal to 0.1000. Separability was affected when the electrolyte concentration of lanthanons and/or current density was varied. (auth)

**32056** THE LATTICE SPACINGS OF SOME CERIUM-RICH, CERIUM-RARE EARTH ALLOYS. K. A. Gschneidner, R. O. Elliott, and M. Y. Prince (Los Alamos Scientific Lab., N. Mex.). p.71-86 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The lattice spacings of cerium-rich, Ce–Sc, Ce–Y, Ce–La, Ce–Pr, Ce–Gd, Ce–Dy, and Ce–Lu alloys were measured. The deviations of the lattice spacing versus composition curves from Vegard's linear approximation were examined from several approaches. (auth)

**32057** THE SYSTEM YTTRIUM–NEODYMIUM. C. G. Kirkpatrick and B. Love (Nuclear Corp. of America, Phoenix, Ariz.). p.87-103 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The system yttrium–neodymium is characterized by a uniform decrease in melting point from yttrium to neodymium, by significant solubility of yttrium in neodymium and of neodymium in yttrium, and by the presence of an intermediate phase near the equal atomic percent composition. The addition of 10% or less of yttrium does not effect an alpha-beta transus of neodymium. The data were obtained by metallographic, thermal, and x-ray analysis; the intermediate phase having the samarium structure was found to decompose at approximately 550°C. Some x-ray diffraction examination was conducted at elevated temperatures. All alloy compositions were metallic in appearance and had the silvery luster, typical of the individual elements. Determination of terminal solubilities and compositional limits for the intermediate phase are the subject of current investigations by magnetic techniques. (auth)

**32058** FABRICATION OF YTTRIUM METAL. A. L. Geary, E. S. Guidoboni, and P. Lowenstein (Nuclear Metals, Inc., Concord, Mass.). p.105-24 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

Techniques are described for the economical fabrication of wrought yttrium. The fabrication process consists of: (a) primary extrusion breakdown of the cast ingot, (b) secondary extrusion to a semifinished shape, and (c) swaging, drawing, or rolling to finished shapes and dimensions. Procedures are given for each step in the process. The mechanical properties, surface quality, and grain structure of the finished products are also described. (auth)

**32059** SOLUBILITY OF THE RARE-EARTH METALS IN LIQUID CADMIUM. I. Johnson (Argonne National Lab., Ill.). p.125-31 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The solubility of the rare-earth metals (except promethium) in liquid cadmium was measured over the temperature range from 325 to about 550°C. The equilibrium solid phases at the lower temperatures were found to be $MCd_{11}$ compounds (cubic $BaHg_{11}$ type) for the light rare-earth metals up to samarium. The $MCd_6$ intermetallic phase (cubic $CeCd_6$ type) is the equilibrium solid phase at the lower temperatures for the heavy rare-earth metals from gadolinium and heavier and for samarium above 420°C. Europium is an exception; the equilibrium solid phase is $EuCd_{11}$ (tetragonal, $BaCd_{11}$ type). The solubility of ytterbium is higher than the solubility of neighboring elements. The relative solubilities are discussed in terms of the pertinent thermodynamic quantities. (auth)

**32060** GADOLINIUM ALLOYS OF IRON, CHROMIUM, NICKEL, AND STAINLESS STEEL. M. Copeland and H. Kato (Bureau of Mines, Albany, Oregon). p.133-41 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

Since the pseudobinary stainless steel–Gd system exhibited complexities, investigations were also conducted on the binary systems Fe–Gd, Cr–Gd, and Ni–Gd. The resulting phase diagrams are given and described in detail. It is concluded that all the alloys have poor corrosion and oxidation resistance except the stainless steels with low Gd content. (D.L.C.)

**32061** SOLID-STATE ELECTROREFINING OF RARE-EARTH METALS. J. D. Marchant, E. S. Shedd, and T. A. Henrie (Bureau of Mines, Reno, Nev.). p.143-50 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

Cerium metal was successfully refined with respect to iron, carbon, and copper by passing direct current through a bar at a temperature of 600°C. Iron, carbon, copper, and silicon migrate toward the anode. Molybdenum, magnesium, and calcium were relatively unaffected by the treatment. The concentration of impurity iron at the anode was 100 times that at the cathode. A radio-tracer technique was used to follow the iron migration. (auth)

**32062** VAPOR PRESSURE OF PRASEODYMIUM AND NEODYMIUM. J. F. Nachman, C. E. Lundin, and A. S. Yamamoto (Univ. of Denver). p.163-73 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The vapor pressures of praseodymium and neodymium were determined in the temperature range of 1724 to 1874°K and 1638 to 1791°K, respectively. The Knudsen effusion method was employed to conduct the study. The weight of the effused vapor was obtained by condensation on a target which was attached to a vacuum analytical balance. The relationships between vapor pressure (mm Hg) and temperature (°K) for praseodymium and neodymium were determined as follows: Praseodymium: $\log_{10} p = (-18{,}453 \pm 424)/T + (8.34 \pm 0.24)$. Neodymium: $\log_{10} p = (-18{,}373 \pm 482)/T + (9.57 \pm 0.28)$. Heats of vaporization were determined from the slopes of the vapor pressure lines; for praseodymium, $\Delta H_V^0 = 84.42 \pm 1.94$ kcal/mole (1724 to 1874°K); for neodymium, $\Delta H_V^0 = 84.06 \pm 2.21$ kcal/mole (1638 to 1791°K). The value of $\Delta H_{298}^0$ for neodymium was calculated by the third-law method to be 76.4 kcal/mole. (auth)

**32063** DISTILLATION OF RARE-EARTH METALS. A. H. Daane, C. E. Habermann, and D. H. Dennison (Iowa State Univ., Ames). p.175-84 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962. (IS-325)

A review is presented of high-vacuum distillation as a method of preparing high-purity rare earths. The history of the discovery of rare-earth volatility is outlined. Distillation was used to improve the ductility of yttrium. A distillation apparatus is described for the light rare earths having low vapor pressures and low melting points. The use of distillation to separate the rare earths is discussed. A table of the conditions utilized in the vacuum distillation of the rare earths is presented. (D.L.C.)

**32064** A CONTRIBUTION TO THE THEORY OF THE SOLUTION OF HYDROGEN IN THE RARE-EARTH ELE-

MENTS. W. M. Mueller (Univ. of Denver) and R. Speiser. p.185-96 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The solubility of hydrogen in the rare-earth metals is related to structural considerations. Observations of the influence of Pauling valence, d-character, and electronegativity are made. (auth)

**32065** LOW-TEMPERATURE SPECIFIC HEAT OF HOLMIUM METAL. J. E. Gordon, C. W. Dempesy, and T. Soller (Amherst Coll., Mass.). p.203-12 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The specific heat of holmium was measured between 0.95 and 14°K. It is found that the nuclear hyperfine contributions is the predominant term in the specific heat at temperatures below 4°K. The specific heat below 1.5°K appears to be that of an ideal paramagnetic gas of spin $^7/_2$. The data above that temperature cannot be regarded as a sum of hyperfine, lattice, electronic, and spin-wave terms. (auth)

**32066** GYROMAGNETIC RATIOS OF FREE TRIPOSITIVE RARE-EARTH IONS. S. Arajs and R. V. Colvin (U. S. Steel Corp., Monroeville, Penna.). p.215-24 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

Calculations of the gyromagnetic ratio G, defined as a ratio of the magnetization and the corresponding angular momentum were made between 10 and 2000°K for the electronic configurations $f^1$, $f^2$, . . ., $f^{13}$. These computations were carried out within the framework of the Van Vleck theory of paramagnetism of localized electrons. The behavior of the gyromagnetic ratio of $Eu^{3+}$ and $Sm^{3+}$ ions is quite different in comparison with the rest of the tripositive rare-earth ions. The G vs T plots, where T is the absolute temperature, have a maximum for $Sm^{3+}$ ions. The quantity G for $Eu^{3+}$ ions decreases with increasing temperatures. The room-temperature value of G for tripositive europium is considerably larger than for other rare-earth ions. For $Ce^{3+}$, $Pr^{3+}$, $Nd^{3+}$, $PM^{3+}$, and $Tb^{3+}$ ions, G increases with increasing temperatures but is practically constant for $Gd^{3+}$, $Dy^{3+}$, $Ho^{3+}$, $Er^{3+}$, $Tm^{3+}$, and $Yb^{3+}$ ions. The calculations are compared with all the known and very limited experimental studies. The agreement is satisfactory. (auth)

**32067** HYPERFINE COUPLING IN ERBIUM AND DYSPROSIUM AS DETERMINED BY SPECIFIC-HEAT MEASUREMENTS. R. D. Parks (Stanford Univ., Calif.). p.225-32 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The specific heats of erbium and dysprosium were measured in the temperature range 0.4 to 4.2°K. The hyperfine contribution to the specific heat was found to be $\Delta C/R = 2.7 \times 10^{-3}/T^2$ for erbium and $\Delta C/R = 2.6 \times 10^{-3}/T^2$ for dysprosium. This corresponds to an effective magnetic field at the nucleus of $9.0 \times 10^6$ gauss for erbium and $6.6 \times 10^6$ gauss for dysprosium. For erbium the spin-wave contribution to the specific heat was found to be $\Delta C/R = 1.9 \times 10^{-3}/T^5$. For dysprosium a reliable value for the spin-wave contribution could not be obtained because of anomalous behavior in the specific heat between 2 and 4°K. (auth)

**32068** STUDIES ON THE SELENIDES AND TELLURIDES OF SELECTED RARE-EARTH METALS. J. F. Miller, L. K. Matson, and R. C. Himes (Battelle Memorial Inst., Columbus, Ohio). p.233-48 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

Four binary crystalline phases were prepared and identified in the Gd–Te system: GdTe, a phase which persists over the $Gd_3Te_4$–$Gd_2Te_3$ range of composition, $GdTe_2$, and $GdTe_4$. Two comparable phases were thus identified in the Ce–Se, Ce–Te, Nd–Te, Sm–Te, and Gd–Se systems. X-ray diffraction data confirm that generally the MX compositions have the NaCl structure and the $M_2X_3$ compositions have the body-centered cubic $Th_3P_4$-type structure. Sound bulk specimens suitable for electrical-property studies were prepared by zone melting the materials in tubular tantalum containers. Results of chemical analyses indicate that the materials tend to lose metalloid when melted in vacuum or an inert atmosphere; however, shift in composition was generally only 0.1 to 0.3 per cent by weight for the gadolinium and neodymium tellurides. Melting points of the materials were in the range 1400 to 2050°C. Trends in electrical properties follow a pattern which appears to correlate with the M-X ratio and the stable valence states of the rare-earth elements. In systems involving rare-earth elements which exhibit no stable oxidized state below the trivalent (cerium, neodymium, and gadolinium), room-temperature resistivities and Seebeck coefficients typically increase as the metalloid-metal ratio is increased from 1 to 1.5. In the systems involving rare-earth elements which exhibit a stable divalent state (samarium and ytterbium), highest electrical resistivities are observed for the MX compositions. (auth)

**32069** PHYSICAL PROPERTIES OF BARIUM-DOPED CERIUM SULFIDE. S. W. Kurnick, R. L. Fitzpatrick, and M. F. Merriam (General Dynamics Corp., San Diego, Calif.). p.249-60 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

Solid solutions of barium sulfide in the thorium phosphide phase of cerium sulfide were prepared by vacuum melting. The resulting materials have the composition $Ce_{2+x}Ba_yS_4$, with $0 \leq x \leq 1$; $0 \leq y \leq 1$; $^2/_3 \leq x + y \leq 1$, and retain the $Th_3P_4$ structure. The addition of barium results in an increase in lattice parameter and changes in electrical transport properties. Electron mobility is also increased substantially and thermoelectric performance at high temperature is likewise enhanced. (auth)

**32070** CERIUM–HYDROGEN AND YTTERBIUM–HYDROGEN SYSTEMS: THE HIGH-PRESSURE REGIONS. K. Hardcastle and J. C. Warf (Univ. of Southern California, Los Angeles). p.261-71 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The cerium–hydrogen and ytterbium–hydrogen systems in the higher pressure regions were examined using a steel pressure bomb. The dissociation pressures of $CeH_3$ are reported for various temperatures. A higher hydride of ytterbium was prepared of composition $YbH_{2.55}$ and found to be a face-centered cubic with a = 5.192 A. Decomposition yielded orthorhombic $YbH_2$, but also a metastable face-centered cubic dihydride of a = 5.253 A. Preliminary NMR and magnetic susceptibility of these rare-earth hydrides are reported. (auth)

**32071** THE ELECTRONIC STRUCTURE OF THE RARE-EARTH METALS. A. R. Mackintosh (Iowa State Univ,, Ames). p.272-84 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

All the evidence shows that the outer electrons in the rare-earth metals can be classified either as 4f or as conduction electrons. The f electrons are important in explaining the magnetic properties of these metals. The effects of 4f and conduction electrons and of alloying on the $\alpha$–$\gamma$ transition of cerium are discussed. Free-electron Fermi surfaces and Brillouin zones in hexagonal close-packed rare-earth metals are considered. The resistivity of erbium, the thermoelectric power of dysprosium, and

the mechanical properties of the rare earths are interpreted in terms of the theory. The problem of determining the electronic structure of the rare earths is discussed briefly. (D.L.C.)

**32072** RARE-EARTH BORIDES FOR NUCLEAR APPLICATIONS. E. W. Hoyt (General Electric Co., Pleasanton, Calif.). p.287-99 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The combination of some of the rare earths with boron would provide a long-lived absorber with very desirable neutron absorption characteristics. The work reported deals with the behavior of some of the rare-earth borides under irradiation and in environments likely to be encountered in nuclear reactors. (auth)

**32073** HYDRATION RESISTANT COMPOSITIONS OF DYSPROSIUM OXIDE–TITANIA. H. E. Perrine (General Electric Co., Pleasanton, Calif.). p.301-10 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

Approximately a 1:2 mole ratio of $Dy_2O_3$–$TiO_2$ (75.7 wt % $Dy_2O_3$) was found to be hydration resistant in autoclave testing at 400°C at 1500 psi. Smaller amounts of titania (varied in 2.5 and 10 mole % steps) show less satisfactory hydration resistance. The suitability of this $Dy_2O_3$–60 mole % $TiO_2$ composition as a control material for use in both boiling-water and gas-cooled reactors was demonstrated by long-term hydration testing and confirmed by metallography and x-ray data. It also appears that silica can be used to stabilize dysprosium oxide against hydration. Limited data indicate that material with less than 60 mole % $TiO_2$ additive may also be suitable for use in gas-cooled reactors. (auth)

**32074** CERTAIN MIXED HYDRIDE-CHALCOGENIDE RARE-EARTH COMPOUNDS. F. L. Carter (Westinghouse Electric Corp., Pittsburgh). p.311-20 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The use of rare-earth hydrides as an intermediary in the preparation of rare-earth semiconducting compounds has led to the discovery of a compound approximating the formula CeHO. Similar compounds prepared to date include $LaH_xO$, $PrH_xO$, $LaH_xTe$, and $PrH_xTe$ where x seems to vary from 0.6 to 1.4. Preparation of analogous sulfur and selenium compounds has not yet been successfully concluded. (auth)

**32075** THE CRYSTAL STRUCTURE OF THE "VATERITE" TYPE RARE-EARTH BORATES. F. Bartram and E. J. Felten (General Electric Co., Cincinnati). p.329-38 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The structure of rare-earth borates is similar to that of $CaCO_3$. The lattice parameters of the borates isostructural with vaterite ($\mu$-$CaCO_3$) are tabulated, and $YBO_3$ and $LuBO_3$ were investigated in detail. Tables of structure factors and interatomic distances are given. (D.L.C.)

**32076** ON RARE-EARTH OXIDE SYSTEMS. L. Eyring (Arizona State Univ., Tempe). p.339-54 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962.

The rare-earth oxide systems are useful for developing a theory of oxide chemistry. Recent work on the systems is summarized with special reference to Ce, Pr, and Tb oxides. The lower, trivalent, and higher oxides are discussed. Thermal decomposition of oxides, oxygen transport in oxides, oxidation of Pr metal, and electric properties of oxides are discussed. (D.L.C.)

**32077** PROCESS FOR OBTAINING FRITTED BERYLLIUM OXIDE. Roger Caillat, Roger Pointud, Emile Pruvot, and Paul Baradez (to Commissariat à l'Énergie Atomique). Swiss Patent 348,397. Aug. 31, 1960.

Beryllium hydroxide, the greater part of which is in the beta form, is calcined and characterized in that a mineral acid or a beryllium salt of the acid is added to the hydroxide or to the oxide which results from the calcination in such a way that the calcined product contains at least 1% mineral acid ions. The acid or salt is chosen so that the ions are eliminated during the subsequent fritting without leaving a solid residue, and the final product is fritted. (OTS)

## Corrosion

**32078** (AERE-R-4134) THE OXIDATION AND CORROSION OF ZIRCONIUM AND ITS ALLOYS. XV. FURTHER STUDIES OF ZIRCONIUM–NIOBIUM ALLOYS. B. Cox, P. G. Chadd, and J. F. Short (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Aug. 1962. 29p.

The oxidation resistance of binary and ternary zirconium alloys containing 0.5 to 5 wt % niobium and ternary additions of Sn, Cu, W, Mo, Sb, V, Ge, Pd, Pt, Fe, and Mn was studied in steam and air. The lowest oxidation rate was achieved with a Zr–1% Nb–1% Cu alloy. A study of the effect of heat treatment on the alloys showed that either a 24 hour anneal at 580°C, or cold-working of the material results in good oxidation resistance. Some alloys containing high percentages of niobium (20-60 wt %) were examined. All the alloys were susceptible to non-uniform oxidation at long times, leading (in some instances) to cracking of the specimen. Such alloys are not considered reliable for use as structural materials involving long exposures to high temperature water or steam. The rate of hydrogen absorption by alloys containing small additions of niobium was very much less than that found for Zircaloy-2. (auth)

**32079** (NAA-SR-6306) THE SNAP II POWER CONVERSION SYSTEM TOPICAL REPORT NO. 14. MERCURY MATERIALS EVALUATION AND SELECTION. James F. Nejedlik (TAPCO. Div. of Thompson Ramo Wooldridge Inc., Cleveland). Apr. 10, 1961. Contract AT(11-1)-Gen-8, Subcontract N843FS-101221. 50p. (ER-4461)

SNAP II is the designation for a 3 kw nuclear auxiliary power unit to be used in a satellite vehicle. The SNAP II System consists of a reactor heat source, a boiler, a Hg Rankine engine, an alternator, and a condenser. The corrosion and subsequent mass transfer resulting from the use of Hg as the thermodynamic working fluid are important considerations in the selection of materials for the SNAP II System. Consequently, corrosion and mass transfer behavior were under study for the past three years. Recent results of this study are presented and the corrosion mechanisms involved are discussed. (auth)

**32080** (ORNL-TM-328) CORROSION BEHAVIOR OF REACTOR MATERIALS IN FLUORIDE SALT MIXTURES. J. H. DeVan and R. B. Evans, III (Oak Ridge National Lab., Tenn.). Sept. 19, 1962. Contract W-7405-eng-26. 35p.

Molten fluoride salts, because of their radiation stability and ability to contain both Th and U, offer important advantages as high-temperature fuel solutions for nuclear reactors and as media suitable for nuclear fuel processing. Both applications have stimulated experimental and theoretical studies of the corrosion processes by which molten-

salt mixtures attack potential reactor materials. Corrosion experiments with fluoride salts which were conducted in support of the Molten-Salt Reactor Experiment and analytical methods employed to interpret corrosion and mass-transfer behavior in this reactor system are discussed. The products of corrosion of metals by fluoride melts are soluble in the molten salt; accordingly passivation is precluded and corrosion depends directly on the thermodynamic driving force of the corrosion reactions. Compatibility of the container metal and molten salt, therefore, demands the selection of salt constituents which are not appreciably reduced by useful structural alloys and the development of container materials whose components are in near thermodynamic equilibrium with the salt medium. Utilizing information gained in corrosion testing of commercial alloys and in fundamental interpretations of the corrosion process, an alloy development program was conducted to provide a high temperature container material that combined corrosion resistance with useful mechanical properties. The program culminated in the selection of a high-strength Ni-base alloy containing 17% Mo, 7% Cr, and 5% Fe. The results of several long-term corrosion loops and in-pile capsule tests completed with this alloy are reviewed to demonstrate the excellent corrosion resistance of this alloy composition to fluoride salt mixtures at high temperatures. Methods based on thermodynamic properties of the alloy container and fused salt are presented for predicting corrosion rates in these systems. The results of radiotracer studies conducted to demonstrate the proposed corrosion model also are discussed. (auth)

**32081** (ORNL-TM-339) EFFECT OF $CO_2$ ON THE STRENGTH AND DUCTILITY OF TYPE 304 STAINLESS STEEL AT ELEVATED TEMPERATURES. W. R. Martin and H. E. McCoy, Jr. (Oak Ridge National Lab., Tenn.). Sept. 27, 1962. Contract W-7405-eng-26. 40p.

The mechanisms by which the carbon dioxide coolant affects the strength properties of type 304 stainless steel were investigated in the range 1300 to 1700°F (704-927°C). Creep- and stress-rupture results obtained on sheet materials in wet and dry $CO_2$ and argon are compared. The effect of annealing in $CO_2$ on the tensile strength and ductility was also investigated. The question of whether the strengthening observed in $CO_2$ was due to oxidation or carburization was determined. Experiments on the effect of various partial pressures of oxygen in argon showed that the creep rate was minimum at approximately 10 ppm. The creep rate is $CO_2$ at equivalent stress and temperature was lower by a factor of 3 than the minimum rate observed in oxygen. Chemical analyses, metallography, and experiments with carbon showed that carburization occurred in pure flowing $CO_2$ in the temperature range studied. From this evidence it was concluded that the strengthening observed in $CO_2$ was primarily due to carburization. The creep- and tensile-fracture strains were adversely affected by exposure to $CO_2$, with the magnitude of the effect dependent on the time and temperature of exposure. (auth)

**32082** (TID-6408) UNUSUAL OXIDATION STATES ENCOUNTERED IN CORROSION PROCESSES. E. C. Pitzer (Knolls Atomic Power Lab., Schenectady, N. Y.). [July 29, 1960]. Contract W-31-109-eng-52. 8p.

A tabulation of oxidation states of common metals is presented. The effects of corrosion environment on the oxidation state are discussed. (M.C.G.)

**32083** (CEA-tr-A-1148) PROBLÈMES DE CORROSION DANS LES RÉACTEURS À REFROIDISSEMENT PAR DES GAZ OU DE L'EAU. (Corrosion Problems in Reactor Cooled with Gas or Water). V. Cibal and V. Rypar. Translated into French from Werkstoffe u. Korrosion, 13: 1-11(Jan. 1962). 59p.

The corrosion problems in heterogeneous reactors cooled with carbon dioxide or water are reviewed. The materials used in the construction of pressurized $CO_2$-cooled reactors are predominantly Mg- and Be-based alloys and steels. With classical Mg alloys of the Magnox type, the temperatures can go only to 430 to 460°C. For higher temperatures it is necessary to use Be or steels resistant to corrosion. The alloys of aluminum with nickel or zirconium alloys of the Zircaloy or Ozhenite type which, compared with the pure unalloyed metal, do not undergo a catastrophic corrosion show proof of a sufficient resistance in water at 300°C. The corrosion-resistant austenitic steels are very well behaved in water up to 300°C. (tr-auth)

**32084** (EURAEC-227) USE OF PLUTONIUM AS FUEL IN NUCLEAR REACTORS. Quarterly Progress Report, October 1 to December 31, 1961. (Société Belge pour l'Industrie Nucléaire, Brussels). Jan. 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 027-60-7RDB. Includes Appendix: RESEARCH ON COVERING URANIUM-CONTENT CERAMIC PARTICLES BY MEANS OF METALLIC NIOBIUM. Summary of Quarterly Progress Reports Nos. 1 and 2, July 15 to December 31, 1961. Jan. 18, 1962. Contract 066-61-7RDB. 60p. A translation.

The chemistry, preparation, fabrication, properties, and behavior of plutonium carbides, plutonium oxides, uranium carbides, and uranium oxides to be used as reactor fuel materials are studied and described. A study is also made of fuel element matrix material properties and behavior, the materials being chromium-niobium-zirconium alloys, niobium-zirconium alloys, niobium-vanadium-zirconium alloys, and chromium-zirconium alloys. Special emphasis is also given to the covering of uranium dioxide with niobium. (N.W.R.)

**32085** KINETICS OF OXIDATION OF NIOBIUM AND ITS ALLOYS. P. M. Arzhanyy, R. M. Volkova, and D. A. Prokoshkin. Issledovaniya po Zharoproch. Splavam, Akad. Nauk S.S.S.R., Inst. Met. im. A. A. Baĭkova, 7: 214-20(1961).

The oxidation of niobium after alloying its surface with various elements was studied. Niobium of the following chemical composition was used as the material for study: 98.9% Nb, 0.4% Ta, 0.15% Pb, 0.13% Fe, 0.08% N, 0.09% O, 0.01% Si, 0.14% C and $5 \times 10^{-6}$% B. The hardness of the material was 200 kg/mm$^2$. The material was made into specimens, which were subjected to cementation with Si and Ti. The diffusion layer was analyzed metallographically and by x-ray spectral methods, as well as by microhardness measurements. The distribution of the diffusion components through the depth of the protective layer was also measured. The specimens were tested for oxidation by continuous weighing with an accuracy of ±0.0005 g. The oxidized layer was studied metallographically and by means of x-ray and electronographic methods. During saturation of Nb with Ti and Si, diffusion layers of complex structure and composition form. At 900-1100°C, a single layer having a microhardness of approximately 1200 kg/mm$^2$ forms, and at 1200 and 1300°C two layers form, the thickness of the second layer being 5-6 $\mu$. The microstructure and microhardness measurements show that the same phase forms on the surface of saturated specimens at all temperatures and times of soaking. By means of x-ray spectral structural analyses, it was found that the phase consists of niobium disilicide in which Ti is dissolved; this has a hexagonal lattice with parameters a = 4.779 KX and c = 6.493 KX. The Nb content of the second layer is approximately 82%. The phases $Nb_5Si_3$ and $Ti_5Si_3$ have identical crystal lattices. Ti and Nb

form a continuous series of solid solutions, and it was assumed that the second phase consists of a solid solution of $Ti_5Si_3$ and $Nb_5Si_3$. The thickness of the diffusion layers forming on the surface of Nb depends on temperature and time for formation. Niobium surfaces protected by Si and Ti oxidize nearly one and a half times more slowly at 1200°C than ones protected only by Si. The scale formed is thin, strong, and well adherent. (OTS)

**32086** STABILITY OF Zr ALLOYS IN CIRCULATING WATER. N. G. Rassokhin and V. N. Mel'nikov (Moscow Inst. of Power Engineering). Teploenergetika, No. 2, 60-2 (1962). (In Russian)

The effects of local boiling on the corrosion-erosion stability of Zr with 0.95% Nb and on crud deposition on heated surfaces are investigated. A complete absence of erosion was observed at up to 320°C. Crud deposition depends on circulation and heat exchange conditions. (R.V.J.)

**32087** REACTION OF CONSTRUCTION MATERIALS WITH LIQUID METALS. V. I. Nikitin. Teploenergetika, No. 2, 90-2(1962). (In Russian)

The utilization of liquid metals (sodium, potassium and their alloys, bismuth, and lead) as reactor coolants was analyzed, and the mechanism of their reaction with construction materials was studied. The properties of coolants and construction materials, the temperatures and temperature gradients in the system, the rate of flow, and the presence of admixtures are discussed. The corrosion factors for bismuth and lead depend on their affinity to simple diffusion while for sodium and potassium, corrosion depends mostly on the amount of oxygen present. A table is included of maximum permissible temperatures for various construction materials, showing not more than 0.012 mm corrosion after 1000 hr, in molten sodium and lithium. (R.V.J.)

**32088** OXIDATION OF NIOBIUM. T. Gurlen. p.286-300 of "26-y Mezhdunar. Kongress Liteyshchikov, 1959." Moscow, Mashgiz, 1961.

The Nb–O system was found to contain 5 types of oxides: $Nb_2O$, NbO, $Nb_2O_3$, $Nb_3O_5$, $NbO_2$, $Nb_2O_5$. Measurements were carried out as to the degree of oxidation of sheet Nb in $O_2$ at various pressures and durations in the temperature range 150 to 1000°C. The $O_2$ pressure constitutes 760, 100, 10, 1, $10^{-1}$, and $10^{-2}$mm of mercury. The investigation of the iodized specimens was carried out by means of x-ray and electron diffractions, and also by means of an electron and a metallographic microscope. (Referativnyy zhurnal, Metallurgiya, No. 2, 1962)

## Fabrication

*Refer also to abstracts 31364, 31698, 31762, 31763, 31766, and 31767.*

**32089** (ANL-FGF-324) SINTERING OF URANIUM MONOCARBIDE PRECIPITATED FROM LIQUID METAL MEDIA. T. R. Johnson, G. D. White, J. H. Handwerk, and R. Steunenberg (Argonne National Lab., Ill.). June 11, 1962. Contract [W-31-109-eng-38]. 15p. (UAC-6537)

Developmental progress is reported on the use as a fuel of UC material made by precipitation from molten Zn. Discussion is included on experimental results and extrapolation of these results to production. Methods of carbide preparation are also given along with a process flowsheet and carbide properties. (J.R.D.)

**32090** (ANL-FGF-325) FABRICATION AND PROPERTIES OF US AND ThS BODIES. P. D. Shalek (Argonne National Lab., Ill.). June 12, 1962. Contract [W-31-109-eng-38]. 11p. (UAC-6535)

Discussions concerning synthesis of pure US and ThS are presented. Fabrication and evaluation of dense bodies of these materials are also discussed. (J.R.D.)

**32091** (ARF-2244-3) LINER FOR EXTRUSION BILLET CONTAINERS. Interim Technical Documentary Progress Report, June 5, 1962–September 5, 1962. Sheldon A. Spachner (Illinois Inst. of Tech., Chicago. Armour Research Foundation). Contract AF 33(657)-8784. 26p. (ASD-TR-7-945(I))

A container-sleeve-liner assembly was designed which will provide adequate support for ceramic, ceramic coated metal, or metal liners. The design minimizes mechanical property requirements of liner materials, and permits rapid removal of worn or damaged liners. A high-strength stem was designed and fabricated. Technical literature on high-strength materials was reviewed, and high-strength materials producers were contacted to locate sources and assess applicability of existing materials for refractory metal extrusion liner use. (auth)

**32092** (BMI-1594) JOINING ZIRCALOY–STAINLESS STEEL AND SAP ALLOYS BY FRICTION, ROLLING, AND EXPLOSIVE TECHNIQUES. Stan J. Paprocki and Stanley W. Porembka, eds. (Battelle Memorial Inst., Columbus, Ohio). Sept. 4, 1962. Contract W-7405-eng-92. 122p.

Metallurgical bonding of Zircaloy-2 and Type 410 stainless steel tubular assemblies and the end capping of SAP alloy fuel sheaths by cold-bonding methods were investigated as a part of the USAEC/AECL Cooperative Program. Approaches considered included friction bonding and forming, cold roll bonding, modified roll forming, and explosive welding. The feasibility of joining these material combinations by friction bonding was demonstrated; however, complete bonding was not attained because of equipment limitations. Extrusion forming of end caps on SAP alloy fuel sheaths with subsequent forge sealing produced leaktight closures. The studies of cold rolling and roll forming indicated that metallurgical bonding of Zircaloy-2 stainless steel tubular assemblies was not possible with current roll-forming equipment. Good strength and thermal-cycling properties were shown by joints produced by both methods. Joint designs providing high local deformations and utilizing intermediate interfacial materials were evaluated in this study. Explosive welds of Zircaloy-2 and stainless steel in tubular configurations were produced with complete bonds. Such bonds withstood a $\frac{1}{8}$-in.-radius bend in testing. Critical parameters were found to be tube thickness, assembly clearance, and degree of vacuum. (auth)

**32093** (DP-418) ULTRASONIC ENERGY APPLIED TO ALUMINUM EXTRUSION CLADDING OF TUBES. J. Byron Jones, Carmine F. DePrisco, Nicholas Maropis, and John G. Thomas (Aeroprojects, Inc., West Chester, Penna.). Nov. 1959. For Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C. Contract AT(07-2)-1. 48p.

Ultrasonic energy appropriately applied to the die or container of a laboratory-type direct extrusion press effected a marked increase in the free extrusion rate of lead and aluminum billets at a constant extrusion force, and a significant decrease in force at a constant extrusion rate. The same results were obtained in extrusion cladding steel tubes with aluminum. Rate increases were generally 100% or greater, and decreases in force were usually within the range of 10 to 20%. Furthermore, the shape and slope of the extrusion curves were altered. The effect appeared to

be attributable to a reduction of both die friction and container wall friction under ultrasonic influence. (auth)

**32094** (EURAEC-310) SWAGING OF URANIUM DIOXIDE. Quarterly Progress Report No. 7, January 1, 1962 to March 31, 1962. (FIAT. Sezione Energia Nucleare, Turin). Apr. 30, 1962. Work performed under United States–Euratom Joint Research and Development Program. Contract 059-61-7-RDI. 16p. (FN-E-21)

A gamma absorptiometer for non-destructive determination of the $UO_2$ swaged density and uniformity of density along the rod was designed, constructed, and put into operation. The sensitivity of the apparatus is such that differences in $UO_2$ density as low as 0.5% of theoretical density can be detected and recorded. An additional series of 30 reactor length rods (20 with stainless steel clad and 10 with Zircaloy-2 clad) was fabricated for the reproducibility and uniformity study on the vibro-swaging process previously developed. The non-destructive testing of these rods is in progress. Four series of samples were prepared to study the influence of the diameter-to-thickness ratio for Zircaloy-2 tubing. The samples were cold swaged to varying reductions in area with no intermediate annealing. No conclusions of the type previously reported for stainless steel can be drawn from data obtained so far. As expected, tubes with higher dia-to-thickness ratios ruptured with fewer passes through the swaging machine. No cracks or rupture of Zircaloy-2 were observed for reduction of area lower than 20%. Thermal conductivity of swaged $UO_2$ having a density of 90% of theoretical was measured at 600°C. The value obtained (0.026 watt $cm^{-1}C^{-1}$) is approximately 25% lower than figures reported for pellets of the same density. Hardness of cladding after swaging and roughness of inner surface of cladding in contact with swaged $UO_2$ were studied. (auth)

**32095** (HW-34368) GRAIN REFINEMENT PRODUCED BY AN ALPHA PHASE ANNEAL OF BETA PHASE HEAT TREATED AND WATER QUENCHED URANIUM. H. R. Gardner (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Jan. 3, 1955. Contract [W-31-109-eng-52]. 5p.

During an experiment involving alpha phase annealing (at 610 to 655°C for 5 and 10 min) of beta-quenched uranium, it was determined that the relatively coarse, irregular shaped grains (0.08 to 0.150 mm in diameter) in the beta-quenched structure, were replaced by fine equiaxed grains (0.04 to 0.09 mm in diameter). (auth)

**32096** (HW-72086) DESIGN REVIEW OF NPR PROCESS TUBE-TO-NOZZLE JOINTS (ROLL JOINTS). M. C. Fraser (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Jan. 12, 1962. Contract [AT(45-1)-1350]. 18p.

Roll joint (transition between Zircaloy-2 process tubes and carbon steel primary piping) properties are discussed with reference to adequacy for service in NPR primary loop. Properties considered were tensile, creep and fatigue strength, corrosion resistance, joint strength with respect to axial, torsional, bending and pressure stresses and leak tightness as affected by time and temperature. The conclusions are that the 1¼ Cr–½ Mo steel alloy nozzles and the Zircaloy-2 process tubes have properties that are adequate for this service and that the roll joint formed with these two materials has properties that are indicated to be adequate for this service. The roll joint development program is still in progress. (auth)

**32097** (HW-SA-2428) PLUTONIUM FUEL RODS FOR PREPARATION OF TRANSPLUTONIC ELEMENTS. W. J. Bailey (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Feb. 6, 1962. Contract AT(45-1)-1350. 4p.

Production by coextrusion of metallurgically bonded, Al-clad, Al-7.35 wt % Pu alloy fuel rods with integral ends is discussed. The rods had a diameter of 0.94 in., length of, 60 in., and a nominal cladding thickness of 0.070 in. The Pu concentration was maintained at 83.3 g/rod. The coextrusion billets can be assembled with fuel cores in the as-cast condition. The casting hot-tops can be returned to the process stream. The process is useful for preparing transplutonic elements and production of high-exposure Pu. (J.R.D.)

**32098** (LA-2737) FABRICATION OF BORAL CONTROL PLATES FOR KIWI REACTORS. R. W. Keil and G. S. Hanks (Los Alamos Scientific Lab., N. Mex.). Aug. 1962. Contract W-7405-eng-36. 39p.

To meet the need for neutron absorption in the Kiwi reactor, control plates containing $B^{10}$ were fabricated. A powder mix of 80 wt % Al-20 wt % $B^{10}$ was hot pressed to form a rectangular plate 15 in. × 4½ in. × 0.400 in. The plate was canned in flattened Al tubing, heated to 400°C, and reduced by rolling to 0.070-in. thickness. The can was then removed and the sheet further reduced by rolling bare at 400°C to 0.050 in. The final sheet was sheared to 13 in. × 4 in. and formed to a 1⅞-in. radius curvature at 250-300°C. Fastening holes were punched in the curved plate to provide a method of assembly. (auth)

**32099** (NMI-7214) EVALUATION OF ZIRCALOY-CLAD UNALLOYED URANIUM OUTER TUBES NOS. 125, 126 AND 127. W. J. Richmond (Nuclear Metals, Inc., Concord, Mass.). Aug. 24, 1962. Contract [AT(30-1)-1565]. 29p.

Data obtained in the evaluation of extruded Zircaloy-clad U tubes are presented. The tubes were fabricated to demonstrate an improved process for fabricating coextruded, thin-walled unalloyed U outer tubes clad with Ni-free Zircaloy-2, and were processed as irradiation candidates. The evaluation data show that two tubes meet all the specifications for irradiation candidates. One of the tubes is satisfactory in all respects except that its overall bow, 5/32 in., is slightly above the ⅛-in. maximum allowed by the specifications applied when these tubes were processed. Tabulated data concerning the tubes are included. (auth)

**32100** (NOTS-TP-2698) THE USE OF HIGH SPEED STEREOPHOTOGRAPHY IN EXPLOSIVE METAL FORMING. Rolland Gallup and John Pearson (Naval Ordnance Test Station. Inyokern (China Lake), Calif.). July 21, 1961. 19p. (NAVWEPS 7738; AD-261199)

A method is described by which high speed stereophotography and commercial aerial topographic analysis techniques can be used to obtain engineering data in the explosive forming of metal parts and to study the dynamics of the forming process. The instrumentation and techniques for this method are discussed in terms of an actual problem, the explosive free-forming of an aluminum plate. Test results are presented. (auth)

**32101** (NUMEC-P-44) DEVELOPMENT OF PLUTONIUM-BEARING FUEL MATERIALS MONTHLY PROGRESS LETTER FOR MONTH OF JULY 1962. Karl H. Puechl (Nuclear Materials and Equipment Corp., Apollo, Penna.). Aug. 5, 1962. Contract AT(30-1)-2389. 4p.

Major effort during the report period was expended on the preparation and characterization of samples scheduled for in-pile screening tests. Other activities were continued on installation of hot metallographic cell installation and preparation and evaluation of $UO_2$-$PuO_2$ coprecipi-

tation processes. Data obtained in three preparation runs are included. A steady state intermediate production run was used to study the effects of ammonia evolved during the initial stages of mixed oxide precursor conversion on ADU precipitation. To determine whether or not self-reduction occurs, charges of the precursor were thermally decomposed in $N_2$ using fast and slow temperature rises on similar samples. Results are included which indicate that no significant amount of self-reduction occurs under these conditions. Effort is also continuing on development of techniques for producing spherical particles by mechanical agglomeration and sintering, and by plasma torch fusion. (J.R.D.)

**32102** (UCRL-6849) FUEL ELEMENT FABRICATION FOR AN ELEVATED-TEMPERATURE CRITICAL ASSEMBLY. Donald Freitas (California. Univ., Livermore. Lawrence Radiation Lab.). June 11, 1962. Contract W-7405-eng-48. 15p.

In University of California LRL elevated-temperature critical assembly experiments (Hot Box), fuel elements consisting of U foils clad in stainless steel envelopes are used. A description is given of how the foils and the envelopes are prepared and assembled, with special attention given to the problem of the differing thermal expansion characteristics of the metals. (auth)

**32103** (EURAEC-179) FABRICATION OF $UO_2$ AND $UO_2$–BeO MIXED PELLETS. Third Quarterly Report, July 1, 1961 to September 30, 1961. (Battelle Institut e.V., Frankfurt am Main). Oct. 26, 1961. Work performed under United States–Euratom Joint Research and Development Program. Contract 015-60-9RDA. 23p. A translation.

Information concerning a thermal conductivity measuring apparatus, by means of which the absolute conductivity is established by the radial heat flux method. A description of the apparatus is included. Other discussion is included on compacting and sintering tests in the development of fabrication methods for thermal conductivity samples of $UO_2$ and $UO_2$-BeO mixtures. These tests were aimed at producing conditions which result in sinters of invariable density, so that the effective influence of BeO additions on the thermal conductivity can be established and other factors, such as porosity and crystallite size can be excluded. This was achieved by maintaining the sintering conditions constant in the case of $UO_2$ and all mixtures containing BeO by varying the compacting pressure. The fabrication of samples containing drilled holes 0.5 mm in diameter to hold insulated thermo-elements is discussed and the pressing tool developed for this purpose is described. (auth)

**32104** PROCESSING OF SPECIAL MATERIALS FOR NUCLEAR REACTORS. Riv. ing., 10: 361-71(1960). (In Italian)

Recent studies on the processing and working of various special reactor materials are summarized with a discussion of the cutting force, power needed, resistance and softness of the material, and other such properties. Problems of toxicity and radioactivity related to processing and special materials are also discussed. The materials considered are Zircaloy-2, aluminum X-8001, concrete, graphite, tungsten alloys, and uranium. (J.S.R.)

**32105** MECHANICAL JOINTS BETWEEN ZIRCALOY AND STAINLESS STEELS. D. L. Paterson and R. Westwood (Canadian Westinghouse Co. Ltd., Hamilton, Ont.). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 14p. $0.50.

In order to permit the utilization of Zircaloy for the in-reactor portions of reactor coolant tubes or test loops, transition joints are required between these components and out-reactor piping of ferrous-base alloys. Such joints must possess high strength and be leak tight for extended periods of service under varying conditions of temperature and pressure. Metallurgical joining techniques are generally unacceptable for this application but mechanical joints have been successfully employed. A number of alternative mechanical joint designs are reviewed. (auth)

## Properties and Structure

*Refer also to abstracts 31372, 31379, 31723, 31768, and 31828.*

**32106** (AD-271937) RESEARCH ON PHASE EQUILIBRIA BETWEEN BORON OXIDES AND REFRACTORY OXIDES, INCLUDING SILICON AND ALUMINUM OXIDES. Quarterly Progress Report No. 9, October 1, 1961–December 31, 1961. W. C. Beard, W. C. Butterman, D. E. Koopman, H. E. Wenden, and W. R. Foster (Ohio State Univ. Research Foundation, Columbus). Jan. 15, 1962. Contract AF 33(616)-6509. 20p.

Studies on phase equilibria in the systems $TiO_2-B_2O_3$, $ZrO_2-B_2O_3$, $HfO_2-B_2O_3$, and $ThO_2-B_2O_3-Na_2O$ are summarized. A literature survey for each of the systems was also made and is presented. (P.C.H.)

**32107** (AECL-1571) CRYSTAL DYNAMICS FROM NEUTRON SPECTROMETRY. A. D. B. Woods (Atomic Energy of Canada Ltd., Chalk River, Ont.). 1962. 37p.

The lattice dynamics of various crystals including lead, sodium, alkali halides, semiconductors, and other more complex compounds were investigated by neutron scattering. Analysis of the low temperature results (~100°K) gives considerable insight into the nature of the interatomic forces. In sodium, a simple metal, the interatomic forces are very nearly derivable from a potential. Lead, a more complicated metal, has extremely long range forces accompanied by strong electronic effects. At higher temperatures anharmonic effects are very pronounced in both metals, especially in lead. The alkali halide results can be interpreted on a "shell" model, with polarizable ions. Even at low temperature neutron groups corresponding to the longitudinal optical modes have temperature dependent widths which are not yet fully understood. (auth)

**32108** (AERE-M/R-2840) TRANSFORMATION OF METASTABLE PHASES IN THE URANIUM–MOLYBDENUM ALLOY SYSTEM. R. F. Hills, D. R. Harries, D. J. Hodkin, and M. B. Waldron (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Mar. 1959. 33p.

The transformation of three metastable phases in quenched Mo–U alloys was studied using metallographic, x-ray, and hardness techniques. At 450°C, transformation of the metastable phases in the 5, 10, and 15 at.% molybdenum alloys to the equilibrium $\alpha + \gamma'$ structure was accompanied by marked increases in hardness. The metallographic changes accompanying transformation in the 5 and 10 at.% molybdenum alloys were not sufficient to account for the hardness changes and it is inferred that sub-microscopic particles of an unidentified phase were precipitated. Transformation of the 25 and 30 at.% molybdenum alloys was accompanied by only minor changes in hardness. However, two metallographic forms of the $\gamma'$ phase were obtained in the 25 at.% molybdenum alloy when transformed at 450 and 550°C, respectively. At 450°C the $\gamma'$ had a banded appearance whereas at 550°C

it was acicular. The x-ray identification of the equilibrium $\alpha$ phase in the 25 at.% molybdenum alloy transformed at 550°C for times in excess of 100 days was in agreement with the equilibrium diagram proposed for the Mo–U system in which the $\gamma$ decomposed by an eutectoid reaction to $\alpha$ and $\gamma'$. (auth)

**32109** (AERE-R-3993) BISMUTH IMPREGNATION STUDIES OF VIRGIN AND OXIDIZED NUCLEAR GRADE GRAPHITE. G. F. Hewitt and E. W. Sharratt (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). June 1962. 20p.

Samples of virgin and oxidized nuclear grade graphite from two sources were impregnated with molten Bi at various pressures. Subsequent cooling led to the solidification of the Bi in the pores of the graphite, and the samples were sectioned for examination of the pore structure. The entrance diameter of the pores impregnated was calculated from the impregnation pressure, the surface tension of the Bi and the Bi/graphite contact angle. It was found that radiography provided the best method of examining sections of the impregnated samples. A technique of stereoscopic radiography allowed a three dimensional picture of the pore structure to be obtained. These examinations provided a qualitative picture of the pore structure and on the modifications produced by oxidation. These modifications depend upon the conditions of oxidation. (auth)

**32110** (CEND-123) THE DEVELOPMENT AND TESTING OF HOMOGENEOUS CERAMIC FUELS. Quarterly Report, December 1, 1960–February 28, 1961. (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.). Mar. 1961. Contract AT(30-1)-2379. 45p. (NYO-2994)

Activities in a program of study on the phase relations of the $UO_2-ZrO_2-CaO$ and $UO_2-CeO$ systems are reported. A problem concerning a glassy phase formation in $UO_2-ZrO_2-CaO$ caused by reaction with the impure $ZrO_2$ setter plate was resolved by use of a Mo boat in direct contact with the specimens. Compacts free of the glassy phase were prepared by $H_2$ sintering at 1700 to 1750°C to densities of 90 to 94% of theoretical. Single-phase, face-centered cubic structures developed by sintering in $H_2$ at 1750°C were thermally stable for compositions up to 15 mole % $UO_2$ after reheating for 28 days at 1000°C in Ar. Two $UO_2-CeO_2$ compositions were sintered to densities of 95 to 98% of theoretical in $H_2$ at 1700°C without glassy phase formation. All specimens containing 7 or 21 mole % of $UO_2$ or $U_3O_8$ were cracked as a result of thermal stress. (J.R.D.)

**32111** (EURAEC-405) FISSION GAS RELEASE FROM URANIUM DIOXIDE. Quarterly Progress Report No. 6, April 1, 1962 to June 30, 1962. (FIAT. Sezione Energia Nucleare, Turin). July 31, 1962. Work performed under United States–Euratom Joint Research and Development Program. Contract 011-60-9-RDI. 29p. (FN-E-26)

Continued operation of the fission gas apparatus is reported. Radiation testing of 5 Mallinckrodt pellets, 3 C.E.A. pellets, and 1 swaged $UO_2$ sample is reported. Data obtained by the past irradiation technique involving sample-container drilling under vacuum, 6-hr diffusion anneal, and fusion with potassium pyrosulfate are tabulated. (J.R.D.)

**32112** (GEAP-3771-3) HIGH PERFORMANCE $UO_2$ PROGRAM. Third Quarterly Progress Report, October–December 1961. B. Weidenbaum (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). Jan. 2, 1962. Work performed under United States–Euratom Joint Research and Development Program. Contract AT(04-3)-189. 28p. (EURAEC-277)

The operating characteristics of uranium dioxide as a reactor fuel are investigated, in particular, fission gas release and central melting in fuel rods. Tests now in progress are discussed. General Electric Test Reactor (GETR) Pressurized Water Loop (PWL) fuel assembly design is given along with the design of the four fuel rods of the assembly. The hydraulic performance of a lead-filled, dummy Zircaloy rod assembly was obtained, to confirm the adequacy of the fuel assembly design. The temperature profile that will exist in the fuel rods during operation at the scheduled heat fluxes is shown. (N.W.R.)

**32113** (HW-56489) HIGH DENSITY CONCRETE MADE WITH HYDROUS-IRON AGGREGATES. Harold S. Davis (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 20, 1958. Contract AT(45-1)-1350. 17p.

Data are presented describing the physical properties of a high-density concrete tested under standard conditions and after heating at temperatures of 85, 200, and 350°C. The concrete has a density of 218 pcf at 85°C and a fixed water content of about 4.3% which makes it a desirable material for constructing biological shields around atomic power reactors. Computed values of attenuation lengths are included for fast neutrons and gamma radiations. (auth)

**32114** (IDO-28591) ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM. EFFECTS OF GAS CORROSION AND AGING ON ML-1 TURBINE ALLOYS. B. E. Farwell and J. S. Brunhouse (Aerojet-General Nucleonics, San Ramon, Calif.). Aug. 1962. Contract AT(10-1)-880. 38p.

Gas corrosion resistance and changes in mechanical properties of alloys to be used in the ML-1 gas turbines are evaluated. The alloys were subjected to anticipated maximum operating conditions in three coolants proposed for ML-1 operation: reference gas (99.5 vol % nitrogen + 0.5 vol. % oxygen), air, and nitrogen. The tests revealed that corrosion of Inconel, Inconel 713C, Incoloy 901, and Type 347 stainless steel was negligible in all coolants after exposure for 5000 hours at 1300°F; corrosion of Type 304 stainless steel (used for piping and tubing only) was negligible after 5000 hours at 900°F. Oxidation of Type 422 stainless steel at 1200°F in oxidizing atmospheres was significant; however, as 1200°F is higher than design conditions (1000°F), it is believed that serious oxidation will not occur during operation. Aging reduced room temperature ductility of Inconel 713C and N-155 (Multimet Alloy) after 5000 hours at 1300°F. (auth)

**32115** (KFK-105) ZWEI- UND MEHRSTOFFSYSTEME MIT PLUTONIUM. LITERATURUBERSICHT, PHASEN-DIAGRAMME UND DATEN. TEIL I. Pu–Ag BIS Pu–Sn. (Binary and Multicomponent Systems with Plutonium. Literature Search, Phase Diagrams, and Data. Part I. Pu–Ag to Pu–Sn). H. Blank, G. Brossmann, and M. Kemmerich (Kernreaktor Bau- und Betriebs-Gesellschaft m.b.H., Karlsruhe, Germany). June 1962. 253p.

A bibliographic survey is made of the phase diagrams and properties of binary and multicomponent systems with plutonium. Data were presented on the following systems: Pu–Ag, Pu–Ag–U, Pu–Ag–Au–U, Pu–Al, Pu–Al–Bi, Pu–Al–Bi–Si, Pu–Al–Ni, Pu–Al–Ni–Ti, Pu–Al–Si, Pu–Al–Zr, Pu–As, Pu–Au, Pu–B, Pu–Be, Pu–Bi, Pu–Br, Pu–C, Pu–C–U, Pu–Ca, Pu–Cd, Pu–Ce, Pu–Ce–Co, Pu–Ce–Cu, Pu–Ce–Fe, Pu–Ce–Ni, Pu–Cl, Pu–Co, Pu–Cr, Pu–Cs, Pu–Cu, Pu–F, Pu–Fe, Pu–Fe–Fs, Pu–Ga, Pu–Ge, Pu–H, Pu–Hg, Pu–In, Pu–I, Pu–K, Pu–La, Pu–Li, Pu–Mg, Pu–Mn, Pu–Mo, Pu–N, Pu–Na, Pu–Nb, Pu–Ni, Pu–Np, Pu–O, $PuO_2-Al_2O_3$, $PuO_2-UO_2$, $PuO_2-$

$ZrO_2$, Pu–Os, Pu–P, Pu–Pb, Pu–Re, Pu–Ru, Pu–S, Pu–Si, and Pu–Sn. A review is also given of the properties of metallic U and Pu and the oxides, carbides, nitrides, and sulfides of these two elements. (J.S.R.)

**32116** (NAA-SR-Memo-6921) ACCEPTOR DOPANTS FOR LEAD TELLURIDE. J. O. McCaldin (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). Dec. 6, 1961. Contract [AT(11-1)-GEN-8]. 10p.

Alternative P-type dopants such as, Th, P, and As were studied. Ingots were grown from a melt containing one at.% dopant and their electrical properties evaluated. Also, sintered pellets of PbTe were doped by exposure at high temperature to gaseous dopants. In most cases, the doping concentrations obtained were insufficient for SNAP 10A requirements. In the case of As, however, doping of Te-rich PbTe, the desired heavy doping was obtained. These preliminary studies suggest that dopants other than Na might be suitable for SNAP 10A requirements. (auth)

**32117** (NARF-62-12T) HEAT DEPOSITION OF REACTOR NUCLEAR RADIATION IN AEROSPACE-VEHICLE MATERIALS. T. R. Strayhorn (General Dynamics/Fort Worth. Div. of General Dynamics Corp., Fort Worth, Tex.). Sept. 10, 1962. 31p. (MR-N-289)

In order to determine the importance of radiation heating in nuclear-propelled aerospace-vehicle materials, a series of calculations was performed. The temperatures of the materials as a function of reactor power, distance from the reactor, and time were calculated. The results clearly indicate that the radiation heat input to materials in the vehicle must be determined and, where sufficiently great, be considered in the design calculations. (auth)

**32118** (NASA-TN-D-998) MEASUREMENTS OF TOTAL EMITTANCE OF SEVERAL REFRACTORY OXIDES, CERMETS, AND CERAMICS FOR TEMPERATURES FROM 600°F TO 2,000°F. William R. Wade and Wayne S. Slemp (National Aeronautics and Space Administration. Langley Research Center, Langley Field, Va.). Mar. 1962. 35p. (AD-272614)

Experimental measurements of total emittance are presented for refractory materials believed to have possible use as temperature control surfaces for high supersonic and hypersonic aircraft. The materials include chemically oxidized Inconel, chromium oxide base paint, aluminum oxide base paint, silicon carbide and silicon nitride ceramics, chromium/aluminum oxide cermets, and flame-sprayed cermets. The total emittance ranges for the materials were 0.91 to 0.94, 0.78 to 0.94, 0.82 to 0.83, 0.94 to 0.62, 0.89 to 0.78, 0.76 to 0.94, and 0.84 to 0.94, respectively. (P.C.H.)

**32119** (ORNL-TM-336) EVALUATION OF SUBSIZE IZOD SPECIMEN DESIGNS FOR DETERMINING THE NOTCH TOUGHNESS OF ZIRCALOY-2. J. J. Prislinger (Oak Ridge National Lab., Tenn.). Oct. 1, 1962. Contract W-7405-eng-26. 16p.

Correlations were made on Zircaloy-2 Izod impact data and Charpy-V drop-weight data. Subsize Izod impact specimens of various geometries and notch configurations and standard ASTM Charpy-V specimens were prepared from bar and plate stock and tested. Drop-weight tests were also conducted and the NDT (nil-ductility transition) temperature was determined for ½ in. Zircaloy-2 plate. Results show that the impact properties of Zircaloy-2 are sensitive to hydrogen concentration, specimen and notch geometry, and specimen and notch orientation. No subsize specimen design was found which yielded impact curves similar to those obtained with standard Charpy-V notch specimens, but designs suitable for in-pile testing were found. It was found that Zircaloy-2 has the property of arresting a moving crack even at temperatures of –100°C and lower. (P.C.H.)

**32120** (TID-16597) APPLICATIONS OF ABSORBER MATERIALS IN NUCLEAR REACTOR TECHNOLOGY. W. Kermit Anderson (Knolls Atomic Power Lab., Schenectady, N. Y.). [Sept. 4, 1962]. Contract [W-31-109-eng-52]. 15p.

The neutron absorption (high cross section) materials used for shutting down reactors are discussed with respect to selection and properties. The selection is based on abundance, properties, fabrication technology, and economic aspects. Materials discussed include boron, cadmium, lanthanons, lithium-6, boron-10, cadmium-indium-silver alloys, hafnium, and europium oxide dispersions. (N.W.R.)

**32121** (TID-16704) THE SPECIFIC HEAT OF SIX RARE EARTH METALS BETWEEN 0.4 AND 4°K. O. V. Lounasmaa (Argonne National Lab., Ill.). June 1962. Contract [W-31-109-eng-38]. 8p. (UAC-6508)

Results of heat capacity measurements on samarium, gadolinium, terbium, dysprosium, holium, and ytterbium between 0.4 and 4°K are reported. The magnetic specific heat $C_M$, caused by interatomic exchange interaction between the 4f electronic spins, and the nuclear specific heat $C_N$, due to splitting of the nuclear spin states by the interaction with the 4f electrons, are also calculated and the results are presented. (N.W.R.)

**32122** (UCRL-10398) ON THE NATURE OF DISPERSED PARTICLE STRENGTHENING AT LOW TEMPERATURES (thesis). Jack Blake Mitchell (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 1962. Contract W-7405-eng-48. 32p.

Polycrystalline aluminum-copper alloys containing 4 and 5% copper were given heat treatments designed to develop dispersions of $Al_2Cu$ precipitate particles of various sizes and distributions. Tensile tests were performed on the dispersion hardened alloys at 4.2, 77, 90 and 114°K to determine the strain rate and temperature dependence of the flow stress. The intersection analysis of the tensile data showed that the dispersed particles significantly increase the average effective forest dislocation density produced for a given amount of strain. The increased dislocation density was found to be in qualitative agreement with selected electron-microscope observations of the deformed structure of the alloys. Estimates of contributions to the flow stress arising from effects coincident with the intersection of dislocations and those associated with the build-up of long range stress fields were made. The major strengthening contribution of the dispersed particles during plastic deformation is shown to be due to an increase in the dislocation density associated with relatively high density tangles of dislocations observed to be localized near particles and groups of particles. (auth)

**32123** (AEC-tr-5362) DIFFUSION, RECRYSTALLIZATION, AND PHASE TRANSITIONS. S. Z. Bokshtein, M. A. Gubareva, S. T. Kishkin, and L. M. Moroz. Translated from p.193-206 of "Proceedings of the Conference on the Use of Radioisotopes in the Physical Sciences and Industry, held in Copenhagen, September 6-17, 1960. Vol. I" (a publication of the International Atomic Energy Agency, Vienna, 1962. (STI/PUB/20(Vol.I(p.193/206)). 15p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 16, as abstract no. 16050.

**32124** (EURAEC-250) DIFFUSION OF FISSION GASES IN SOLIDS. Quarterly Report No. 2 (2nd year) October through December 1961. (Hahn-Meitner-Institut fur Kernforschung, Berlin). Work Performed under United States–Euratom Joint Research and Development Program. Contract 064-61-8-RDD. 14p. A translation.

The diffusion of Ar in KCl monocrystals, measured between 400 and 700°C, is in accordance with theory. Interpretation is now in progress. In the case of UC45, the Xe released was observed to behave in a way which is not directly amenable to interpretation according to the diffusion theory. There is no appreciable change in this behavior after repeated irradiation and heating. It was possible to heat UC by high frequency in Ta tubes up to 1600°C without causing any changes, although with $Al_2O_3$ and $ZrO_2$, on the other hand, it reacted, with considerable release of rare fission gases. Tests were also carried out in $ThO_2$ at 200 to 800°C. F. values of $2 \times 10^{-4}$ to $7 \times 10^{-3}$ were measured. For the purpose of determining the total activity of the rare fission gases, a reference sample of $UO_2$ or $ThO_2$ dissolved in solid potassium pyrosulphate is being irradiated. The rare fission gases are released by melting the sample at 800°C in a vacuum. In view of the good results obtained, a second high-frequency heating apparatus was constructed, with which a temperature of 2300° can be attained. (auth)

**32125** (EURAEC-296) DIFFUSION OF FISSION GASES IN SOLIDS. Quarterly Report No. 3 (2nd Year) January through March 1962. (Hahn-Meitner-Institut fur Kernforschung, Berlin). Work Performed under United States–Euratom Joint Research and Development Program. Contract 064-61-8-RDD. 10p. A translation.

A high-vacuum apparatus was built for the high-frequency heating of one or of two samples simultaneously to over 2000°C. The system was tested with $UO_2$, UC and $ThO_2$ crystals. The Ar diffusion tests with KF and KCl monocrystals were systematically pursued and evaluation completed by means of the Siemens digital computer. Compacted KCl tablets displayed the same behavior as that observed in other polycrystalline materials, i.e., rare gas is given off continuously when the temperature is increased. The $UO_2$ monocrystalline balls supplied by Euratom were heated at $10^{-3}$ torr. to 1710°C without any change in form. The evaluation of these diffusion tests at 1560 to 1710°C will be given in the next Quarterly Report, together with that of tests on crystalline thorium oxide at similar temperatures. The UC45 tests were concluded. The UC tests showed that Ta does not react with UC below 1800°C but that above this temperature it must be replaced by W. Xenon release follows the theoretical pattern, but part of the Xe is released spasmodically at 900 to 1400°C when the sample is subjected to the first temperature rise. The provisional results are referenced. A discussion of the effect of this spasmodic release, which is superimposed on the actual volume diffusion, on the evaluation method in a hypothetical case is also referenced. (auth)

**32126** (EURAEC-328) RESEARCH INTO ZIRCONIUM HYDRIDE IN ZIRCALOY-2 AND Zr–Nb ALLOYS. Quarterly Report No. 2, January 1, 1962 to Mar. 31, 1962. (Siemens-Schuckertwerke A. G., Erlangen, Germany). Work performed under United States–Euratom Joint Research and Development Program. Contract 024-61-10-RDA. 43p. A translation.

An investigation of $H_2$ distribution in Zircaloy-2 under a temperature gradient was scrapped, because this problem is considered essentially solved. The metallographical investigation of the as-received conditions of the Zry-2, ZrNb 1 and ZrNb 2.5 plates was concluded. Samples are discussed with regard to the type of fusion, impurities, manner of separation, and hardness. The results are shown in detail. In addition to the $H_2$ absorption by Zr alloys through superheated steam corrosion, the loading method through annealing in $H_2$ was investigated. The apparatus built for this purpose is described, the loading method indicated, and the associated problems and present status discussed. (auth)

**32127** (JPRS-14484) EXPERIMENTAL PREDICTION OF THE APPROXIMATE MELTING POINTS OF CERTAIN ALLOYS BELONGING TO THE SYSTEM Ni–Ti–Cr–Mo–W–Nb. F. M. Perel'man. Translated from Zhur. Neorg. Khim., 7: 844-9(1962). 16p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 16, as abstract no. 19411.

**32128** X-RAY STUDY OF PYROLYTIC GRAPHITES. O. J. Guentert (Raytheon Co., Waltham, Mass.). J. Chem. Phys., 37: 884-91(Aug. 15, 1962).

A picture of the structure of pyrolytic graphites was obtained from an x-ray study of several samples deposited under various conditions at temperatures ranging from 1700 to 2500°C. The structural features investigated include preferred orientation, layer order, and crystallite sizes and strains perpendicular and parallel to the basal layers. Deposits made at 1700°C show preferred orientation of the order of 10:1, crystallite dimensions below 100 Å, nearly random layer order, and high strains in the c direction. In materials deposited at 1900°C and higher, the preferred orientation is sharply increased to values between $10^3$:1 and $10^4$:1, and representative values for the crystallite dimensions $\bar{L}_c$ and $\bar{L}_a$ are 200 and 265 Å, respectively. The layer order remains nearly random, however, the c-direction strains show only a slight reduction. The basal layers themselves are approximately strain-free. (auth)

**32129** EVOLUTION OF THE HEAT TREATMENT OF URANIUM MONONITRIDE. A. Accary and M. Marchal (Commissariat à l'Energie Atomique, Centre d'Études Nucléaires, Saclay, France). Mém. sci. rev. mét., 59: 57-70 (1962). (In French)

A statistical and a morphological study of grain growth under thermal treatment of UN, prepared by fritting under pressure, lead to the following conclusions. The growth passes through two successive stages, the first constituted by a recrystallization which substitutes a matrix free from stresses with the work matrix. The second stage leads to a rearrangement of grain boundries. During grain growth, two families of grain characterized by different growth velocities were detected. The constant approximate velocity of surface growth was measured, and it was shown that it is dependent on two different activation heats, according to whether it is measured in the first or second growth stage. (tr-auth)

**32130** ORIENTATION DEPENDENCE OF STRUCTURE IN PYROLYTIC GRAPHITE. Robert H. Bragg and Charles M. Packer (Lockheed Missiles and Space Co., Sunnyvale, Calif.). Nature, 195: 1080-2(Sept. 15, 1962).

An x-ray investigation of nucleated pyrolytic graphite was conducted in which preferred orientation and the orientation dependence of individual crystallites after heat treatment were measured. The results show that a sharp change in layer stacking order in a temperature range above 2000°C occurs in all graphitization processes. A stress relief mechanism appears to be consistent with the observed behavior. (D.L.C.)

**32131** NEW MOLTEN REFRACTORY PRODUCTS FOR GLASS FURNACES. S. S. S. Meloyan. Ogneupory, No. 12, 558-60(1961). (In English)

The production and development of molten refractory products is described with special emphasis on alumina, kaolin, and zirconic concentrates as charge components. The refractory materials are called baddeleyite corundum or Bakor in short, as their crystalline phases represent baddeleyite ($ZrO_2$) and corundum ($\alpha$-$Al_2O_3$). The service life of Bakor in glass furnaces is 20–30 months at 1480–1500°C. Experiments were made for the production of Bakor-33, which contains about 33% $ZrO_2$, 50% $Al_2O_3$, and 12–13% $SiO_2$. Industrial alumina, zircon free from iron, and industrial zirconium dioxide were used as charge components. Additions: marble dust and calcined soda. Bakor-33 is molten at 1900–2000°C and cast at 1800–1820°C. Heat treatment takes 8–10 days. Its specific gravity is 3.6–3.7 g/cm$^3$, the weight of unit volume 3.3–3.6 g/cm$^3$, the maximum apparent porosity 3%, and the softening point at 2 kg/cm$^2$ lies at 1740°C. Analysis: 13.72% $SiO_2$; 49.78% $Al_2O_3$; 0.71% $FeO_3$; 0.84% CaO; 0.11% $TiO_2$; 1.92% alkalies; 32.92% $ZrO_2$. By using Bakor-33 the glass melting temperature can be increased from 1450 to 1600°C and the service life of the glass furnaces to 36–48 months. Main sources of scrap (40%) are cracks, large shrinkage cavities, and convexity of lateral faces, which is mainly caused by the imperfection of the production process. (OTS)

**32132** HARDNESS OF MOLYBDENUM IN THE 20 TO 2500°C RANGE. V. A. Borisenko. Poroshkovaya Met., No. 3, 55-61(May-June 1962).

A study of the temperature dependence of the hardness of molybdenum at 20 to 2500°C was carried out on work-hardened (forged) and annealed specimens of sintered Mo. The results of the measurements are summarized. Analysis of the temperature dependence of hardness and tensile strength showed satisfactory correlation between the hardness and tensile strength on individual portions of the curves, particularly at temperatures over 1000°C (1400°K). The relationship between the tensile strength $\sigma_t$, yield strength $\sigma_y$, and the hardness, H, of Mo for the 1100 to 2000°C range can be expressed by the following equations: $\sigma_t = 0.49$ H kg/mm$^2$; $\sigma_y = 0.45$ (H-6) kg/mm$^2$. (OTS)

**32133** THERMODYNAMIC PROPERTIES OF TUNGSTEN AT 0 TO 2400°C. V. A. Kirillin, A. E. Sheindlin, and V. Ya. Chekhovskoi. Teploenergetika, No. 2, 63-6(1962). (In Russian)

The thermodynamic properties of tungsten were investigated at 0 to 2400°C and the enthalpy was determined at 2000 to 2340°. Experiments were carried out with four specimens with less than 0.05% admixture in a vacuum or in argon at 1.05 atm. (R.V.J.)

**32134** METAL CHEMISTRY OF VANADIUM. I. I. Kornilov and N. M. Matveeva (Baikov Inst. of Metallurgy, USSR). Uspekhi Khim., 31: 1076-1108(1962). (In Russian)

A review is given of physical and mechanical properties of pure (99.7 to 99.9%) V and of metal chemistry and properties of alloyed V. 90 references are included. (R.V.J.)

## Radiation Effects

*Refer also to abstracts 31369, 31371, 31374, 31378, 31380, and 31722.*

**32135** (ANL-6429) THE EFFECTS OF IRRADIATION ON URANIUM–PLUTONIUM–FISSIUM FUEL ALLOYS. Final Report on Metallurgy Program 6.5.5. J. A. Horak, J. H. Kittel, and R. J. Dunworth (Argonne National Lab., Ill). July 1962. Contract W-31-109-eng-38. 18p.

A total of 35 specimens of U-Pu-fissium alloy and 2 specimens of U-10 wt % Pu-5 wt % Mo alloy were irradiated as a part of the fuel-alloy development program for fast breeder reactors at Argonne National Laboratory. Total atom burnups ranged from 1.0 to 1.8% at maximum fuel temperatures ranging from 230 to 470°C. Emphasis was placed on the EBR-II Core-II reference fuel material, which is an injection-cast, U-20 wt % Pu-10 wt % fissium alloy. It was found that this material begins to swell catastrophically at irradiation temperatures above 370°C. The ability of the fuel to resist swelling did not appear to vary appreciably with minor changes in Zr or fissium content. Decreasing the Pu to 10 wt %, however, significantly improved the swelling behavior of the alloy. Both pour-cast and thermally cycled material and pour-cast, extruded, and thermally cycled material appeared to be more stable under irradiation than injection-cast material. Under comparable irradiation conditions, the specimens of U-20 wt % Pu-5 wt % Mo alloy were less dimensionally stable than the U-Pu-fissium alloys investigated. (auth)

**32136** (ANL-6431) IRRADIATION BEHAVIOR OF RESTRAINED AND VENTED URANIUM-2 w/o ZIRCONIUM ALLOY. Final Report–Programs 6.1.22 and 6.1.27. J. A. Horak, J. H. Kittel, and F. L. Yaggee (Argonne National Lab., Ill.). June 1962. Contract W-31-109-eng-38. 39p.

Twelve 0.22-in.-diameter fuel specimens containing a longitudinal central vent and clad with 0.010 in. of Type 304 stainless steel were irradiated to evaluate the effect of restraint and a central vent on fuel element stability. The cladding of 10 of the specimens contained porous end plugs to vent any released fission gas and thus to minimize the buildup of gas pressure within the stainless steel cladding. The specimens consisted of a 20% enriched uranium–2 wt % zirconium alloy core surrounded by a natural uranium–2 wt % zirconium alloy sleeve. Eight of the specimens were irradiated to burnups of the enriched core of 6.9 to 12.8% of all atoms (1.2 to 2.2 at.% of the duplex assembly) at maximum fuel temperatures ranging from 280 to 760°C. Most of the clad specimens exhibited negligible volume increases as a result of irradiation. Two specimens containing central vents but unclad were irradiated together with the clad specimens in an attempt to differentiate between the effects due to a central vent and the effects due to cladding. The central vent in itself did not appear to reduce the swelling characteristics of the alloy. Mechanical restraint appeared to have extended the useful operating temperatures of the metallic fuel alloy by at least 200°C and also greatly extended the burnup levels to which the fuel could be irradiated. (auth)

**32137** (ARL-91) RADIATION EFFECTS ON ORGANIC MATERIALS. Weldon G. Brown (Chicago. Univ.). Dec. 1961. Contract AF 33(616)-3875. 7p. (AD-272213)

Brief summaries describing the principal results of work on a number of separate problems in the general field of organic radiation chemistry are included. The problems discussed are radiation induced reactions of olefins; radiolysis of cyclopentane; radiolysis of liquid CH3OH–inhibitory effects of additives; radiolysis of CH3OH adsorbed in a synthetic zeolite–energy transfer effects; and radiolysis of aralkyl ketones. (auth)

**32138** (BMI-1592) POSTIRRADIATION RELEASE OF XENON-133 FROM SINGLE-CRYSTAL ALPHA ALUMINA. David L. Morrison, Russel H. Barnes, Thomas S. Elleman,

and Duane N. Sunderman (Battelle Memorial Inst., Columbus, Ohio). Aug. 23, 1962. Contract W-7405-eng-92. 31p.

Postirradiation measurements of the release of $Xe^{133}$ recoiled into single-crystal alpha alumina during neutron irradiation in contact with $UO_2$ powder were made at 500 to 1500°C. Exposures of $7 \times 10^8$ to $1.5 \times 10^{16}$ fission-fragment recoils per $cm^2$ were employed. The initial release of $Xe^{133}$ from alpha alumina during a postirradiation heat treatment is very rapid, giving rise to the burst. After several minutes, the release rate decreases, and the cumulative fractional release becomes a linear function of the square root of the heating time. This behavior is observed both during the initial heating of the specimen and during its subsequent heat treatments at higher temperatures. Although the burst effect is not expected from simple diffusion theory, a linear cumulative fractional release with the square root of the heating time is expected. The activation energy calculated from the temperature dependence of the diffusion coefficients derived from the linear portion of the release curves is 64 ± 18 kcal g mole for an exposure of $3 \times 10^{13}$ fission recoils per $cm^2$ at 1040 to 1550°C. An activation energy of 9.2 ± 2 kcal per g mole is calculated for diffusion below 1040°C at this exposure. For higher radiation exposures the low-activation-energy process is absent. (auth)

**32139** (BNL-6247) DYNAMICS OF RADIATION DAMAGE: A REPORT ON RECENT RESULTS AT BNL. George H. Vineyard (Brookhaven National Lab., Upton, N. Y.). [1961]. Contract [AT(30-2)-Gen-16]. 3p.

A brief review of work on radiation damage in metals at low and moderate energies is presented. Work on a model representing Cu is discussed along with damage in a model of ordered $Cu_3Au$. The work is being extended to a model of Fe. (J.R.D.)

**32140** (BNL-6248) THE INFLUENCE OF RADIATION-PRODUCED DEFECTS ON THE PRECIPITATION OF CARBON IN IRON. F. E. Fujita and A. C. Damask (Brookhaven National Lab., Upton, N. Y.). [nd]. Contract [AT(30-2)-Gen-16]. 4p.

The iron-carbon system was selected for the study of radiation-enhanced nucleation. Iron containing approximately 0.01 wt % carbon was quenched from 700°C and irradiated at 57°C. After a 4-hr irradiation the rate of decay of the Snoek internal friction peak was one order of magnitude faster than the rate of decay in an unirradiated specimen. This indicated that in the irradiated specimens there are 10 times more precipitation nuclei than in the unirradiated specimens. This was confirmed by electron microscope studies. When the quenched iron-carbon was irradiated at low temperature (–100°C) an entirely different effect occurred. Measurements of the rate of decay of the internal friction peak after a 12 day low-temperature irradiation showed that the carbon disappears from solid solution over a thousand times faster than in unirradiated form. It is shown that the carbon atoms are trapped by point defects, presumably vacancies. (M.C.G.)

**32141** (CRFD-1092) THE RELATIVE AXIAL EXPANSIONS UNDER IRRADIATION OF STACKS OF $UO_2$ PELLETS IN ZIRCALOY SHEATHS. M. J. F. Notley (Atomic Energy of Canada Ltd., Chalk River, Ont.). Aug. 1962. 25p. (AECL-1598; Exp-NRX-5603)

An experiment was performed to measure the relative axial movement of $UO_2$ fuel pellets inside a Zircaloy sheath. Although the results must be treated with some reservation, the inferences are that there is very little relative movement between the fuel and the sheath when the two are in firm pressure contact. Relative movement was in the range 0.075 ± 0.03 cm for a 30 cm fuel length, and was not greatly affected by the power output, profile of the pellet end-faces or the diametral clearance left between the fuel and the sheath on assembly. However in two elements that had thick sheaths to withstand the coolant pressure and that were assembled with large diametral clearances (2% of the diameter) the available axial clearance for relative fuel/sheath movement (1%) was fully taken up. The thin sheathed elements showed residual axial expansions of up to 0.17 cm, indicating that the pellets move relative to the sheath only until frictional forces are sufficient for the sheath to grip the fuel; thereafter the sheath is extended. The measurements also indicate that sheath elongation is governed by the temperature at the contact points between adjacent pellets, e.g., at the inner edge of a pellet shoulder, as long as that temperature is below approximately 1000°C. At higher temperatures, the $UO_2$ is too plastic to exert sufficient force to strain the sheath. (auth)

**32142** (CVNA-142) RABBIT CAPSULE IRRADIATION OF $UO_2$. Terminal Report. Robert N. Duncan (Westinghouse Electric Corp. Atomic Power Div., Pittsburgh). June 1962. For Carolinas Virginia Nuclear Power Associates, Inc., Charlotte, N. C. Contract AT(30-1)-2289. 119p.

Factors, which affect the thermal performance capability of $UO_2$ fuel rods, were evaluated by a series of short time rabbit capsule irradiation experiments. Six capsules containing three fuel rod samples in each were irradiated for 40 hours at fuel rod power levels of from 11 to 24 (KW/ft) (360 to 785 (W/cm)). The capsules were designed to minimize variation in both radial and axial thermal neutron flux. The fuel rod configuration was a 5 inch column of $UO_2$ pellets, 0.430 inches in diameter, 94 ± 1.5% of theoretical density, clad with Zircaloy-2. The temperature distribution within the $UO_2$ fuel was estimated by post-irradiation measurements of the radius at which various microstructural changes such as grain growth, columnar grain formation, and melting of the $UO_2$ occurred. Comparison of the $UO_2$ microstructures from fuel rods with initial cold diametral gaps of 0.006, 0.012, and 0.025 inches indicated that the $UO_2$ surface and center temperature increased with increasing gap. The $UO_2$ in fuel rods initially backfilled with helium operated at lower temperatures than those containing argon. Results indicate that the thermal conductivity of $UO_2$ at high temperatures is higher than that obtained by extrapolating existing low temperature data. The thermal conductivity of $UO_2$ between 450 and 2760°C ($UO_2$ melting point) is estimated to be 0.030 (W/cm°C) or 1.75 (BTU/hr ft °F). Center melting will occur only at fuel rod power levels of 28 (KW/ft) (860 (W/cm)) or greater for fuel rods with a $UO_2$ pellet surface temperature of 450°C. (auth)

**32143** (DP-251(Del.)) AN X-RAY METHOD FOR PREDICTING THE STABILITY OF NATURAL URANIUM AT LOW BURNUP. Edward F. Sturcken (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). Nov. 1957. Contract AT(07-2)-1. 32p.

A "growth index" for predicting the dimensional behavior of natural uranium at low burnup was developed from x-ray diffraction measurements of preferred orientation. (auth)

**32144** (EURAEC-370) THE EFFECT OF RADIATION ON THE DUCTILE-BRITTLE TRANSITION IN PRESSURE VESSEL STEELS. Quarterly Report No. 6, April 1–June 30, 1962. E. Anderson, W. Bollmann, D. King, M. Malone, and J. Spreadborough (Battelle Memorial Inst. International Div., Geneva). July 1962. Work Performed under United States–Euratom Joint Research and Development Program. Contract 041-60-12-RDS. 41p.

Activities in a program to advance the understanding of pressure vessel steel neutron embrittlement are reported. Results of work concerned with certain aspects of an electron microscopy program are presented. The use of a goniometer made for the Siemens microscope is described. A method was developed for the stereographic analysis of micrographs employing the goniometer together with a procedure based on analytical solid geometry. The dualistic theory of dislocation networks (first described in the Fourth Quarterly Report) is applied to the interpretation of such networks containing precipitates. Techniques are discussed for the preparation of thin foils from irradiated material, suitable for examination by transmission electron microscopy. Detailed descriptions are given of a device for automatically detecting the end of the polishing process and of an improved specimen holder intended for electropolishing radioactive samples. Progress made in the other fields of investigation is outlined. (auth)

**32145** (FZM-1943) THE EFFECTS OF NUCLEAR RADIATION ON AIRCRAFT MATERIALS. Paul W. Vineberg (Convair, Fort Worth, Tex.). Mar. 10, 1960. 61p. (AD-273418)

A report is presented which contains a short description of the various types of radiation, a discussion of the important changes in physical, electrical, and chemical properties found in aircraft materials, and an introduction to the nuclear reactions which cause induced radioactivity. The information was prepared specifically for aircraft engineers, however information on health physics is included to show what effect radiation has on human beings and to outline the measure of protection given by present-day health physics regulations and methods. (auth)

**32146** (GEAP-3743(Pt.III)) RADIATION EFFECTS IN BORIDES. PART III. CRYSTALLOGRAPHIC CHANGES IN IRRADIATED BORIDES. W. V. Cummings (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.) and W. I. Clark (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 31, 1962. Contract AT(04-3)-189. 47p.

Crystallographic changes in several irradiated metal boride systems were studied by x-ray diffraction techniques. Three structures were investigated quite extensively and a fourth examined in a cursory manner. Irradiation damage can be related to structure. The relationship does not depend primarily upon the crystal system, but rather upon the strength of the structure bonds. The metal diborides with their tightly bonded hexagonal structures are most resistant to radiation damage. The hexaborides on the other hand, have a loosely bonded cubic structure and are extensively damaged by radiation. The tetraborides are intermediate in bond lengths and also are intermediate in structure damage. A very limited study was made of irradiated dodecaborides. This face-centered cubic structure has an intermediate bond length between metal and boron atoms but a long bond length between metal atoms. The damage to this structure was apparently quite extensive as determined from the limited data available. (auth)

**32147** (HW-74622) COMBINED EFFECTS OF STRESS AND IRRADIATION ON STRUCTURAL MATERIALS (DEFINITION AND APPROACH). K. R. Merckx and J. C. Tobin (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Aug. 14, 1962. Contract AT(45-1)-1350. 16p.

Information is presented concerning the cumulative effects of simultaneous or repeated application of stress, radiation, and thermal environment on reactor materials such as reactor vessels, structural supports, fuel cladding, thermal shields, in-reactor piping, and joining materials. (J.R.D.)

**32148** (HW-SA-2394) RADIATION EFFECTS IN GRAPHITE. R. E. Nightingale (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 11, 1962. Contract AT(45-1)-1350. 44p.

A review of radiation effects on graphite is presented. Included are discussions of the general relations of these effects with original structural properties, and details of radioinduced changes. Other discussions are devoted to stored energy, annealing, and future problems in the use of nuclear graphite. Data and illustrations concerning structure and radioinduced changes are included. (J.R.D.)

**32149** (HW-SA-2425) THE IRRADIATION TESTING OF A PLUTONIUM FUEL ELEMENT CONCEPT AT HANFORD. W. J. Bailey, M. D. Freshley, and R. E. Sharp (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 8, 1962. 18p. Contract AT(45-1)-1350.

The Al-Pu alloy spike fuel development work is summarized. One of the fuel element concepts developed is a 19-rod cluster, 8 ft long, and about 3 in. in diameter. Elements are being successfully tested under power reactor conditions in the PRTR. Results of irradiation testing are described and shown. (M.C.G.)

**32150** (NARF-62-8T) TENSILE BEHAVIOR AND MOLECULAR CHARACTERISTICS OF IRRADIATED ELASTOMERS. E. G. Fritz and P. M. Johnson (General Dynamics/Fort Worth. Div. of General Dynamics Corp., Fort Worth, Tex.). July 1962. Contract AF 33(657)-7201. 43p. (MR-N-294)

Stress-strain data on reactor-irradiated polyurethane elastomers were analyzed on the basis of the Mooney-Rivlin relationship. Good agreement of the experimental data with the theoretically predicted behavior is demonstrated. According to the molecular implications of this relationship, the total effective crosslinking density was calculated. The results indicate that, upon irradiation to doses on the order of $10^{18}$ ergs/g(C), all Adiprene-L and most Disogrin specimens preponderantly degraded while all Genthane and General Tire Type-R specimens preponderantly crosslinked. A supplementary preliminary analysis of stress-strain data of silicone elastomers via this approach showed, with few exceptions, a radiation-induced increase in the total effective crosslinking density. The limitations of the present analysis are discussed and recommendations are offered for the generation of additional and more refined experimental evidence to corroborate the conclusions of this analysis. (auth)

**32151** (NARF-62-9T) ULTIMATE AND PSEUDO-EQUILIBRIUM TENSILE PROPERTIES OF IRRADIATED ELASTOMERS. E. G. Fritz and P. M. Johnson (General Dynamics/Fort Worth. Div. of General Dynamics Corp., Fort Worth, Tex.). Aug. 1962. Contract AF(657)-7201. 43p. (MR-N-295)

It is shown that the pseudo-equilibrium stress-strain behavior and ultimate strength of a number of commercially prepared and reactor-irradiated vulcanizates (silicones, polyurethanes, natural rubber, NR-neoprene, and NR-SBR blends) follow, in good approximation, the empirically developed relationship $\tau/[2(\alpha - \alpha^{-2})] = CD^{A}$, where $\tau$ = stress or ultimate tensile strength in psi (with reference to the undeformed cross section) at extension ratio $\alpha$, D = absorbed dose in megarads, and C and A = constants. In the cases investigated, A varied from near zero to 0.5. The

relationship is compared with another similar expression. (auth)

**32152** (SCR-532) RADIATION DAMAGE TO SEMICONDUCTOR DEVICES. J. W. Easley (Sandia Corp., Albuquerque, N. Mex.). July 1962. Contract [AT(29-1)-789]. 35p.

Damage caused to semiconductor devices by exposure to radiation is discussed. Displacement effects, surface effects, and ionization effects are described. (M.C.G.)

**32153** (TID-11164) THE EFFECT OF ANISOTROPIC NEUTRON SCATTERING ON RADIATION DAMAGE. P. E. McElligott, K. R. Jordan, and R. J. Allio (Knolls Atomic Power Lab., Schenectady, N. Y.). Nov. 9, 1960. Contract [W-31-109-eng-52]. 18p.

Aspects of predicting the amounts of radiation damage sustained by metals in reactor neutron fluxes are discussed. It is noted that a first-order anisotropic correction factor for the energy exchange in elastic collisions may be obtained from measured or calculated differential scattering cross sections. The discussion is limited to elastic collisions of fast neutrons with energies $0.5 \leq En \leq 5.0$ Mev. The amount of energy transferred to a displaced lattice ion as a result of an elastic collision by a fast neutron is related to the angle through which the neutron is deflected in the scattering event. The average fraction of available energy transferred per neutron collision, (f/2), may be calculated from measured differential scattering cross sections. For the materials investigated, it is found that f may be represented as a decreasing linear function of the neutron energy in the range 0.5 to 5.0 Mev. At a constant neutron energy, the periodic variation in f with atomic mass agrees qualitatively with results based on the optical interaction model of Feshbach, Porter, and Weisskopf. In radiation damage calculations the assumption of isotropic scattering of fast neutrons leads to an overestimate of the number of induced defects in the material. The average errors for eight of nine materials investigated ranged from 23% for a monochromatic 0.5 Mev spectrum to 71% for a 1/E spectrum between 0.5 and 5.0 Mev. (J.R.D.)

**32154** (TID-16641) CORRELATION OF ANISOTROPIC GROWTH OF UNRESTRAINED URANIUM WITH PREFERRED ORIENTATION BY THE GROWTH INDEX CONCEPT. E. F. Sturcken, B. G. LeFevre, and W. R. McDonell (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). [July 1962]. Contract AT(07-2)-1. 25p.

An investigation was conducted to correlate the radiation-induced anisotropic growth and preferred orientation as interpreted by the growth index in unrestrained U. Rods were irradiated in NaK capsules to a burnup of 0.208 at.%. Preferred orientation was controlled in fabrication of the rods and was measured after irradiation. Data on growth indices and rate are included along with observations and photographs. (J.R.D.)

**32155** (UNC-5027) SPONGE FUEL EVALUATION. Phase I Report, April 4, 1959 to June 30, 1961. J. M. McKee (United Nuclear Corp. Development Div., White Plains, N. Y.). Aug. 23, 1962. Contract AT(30-1)-2303. 109p.

Metallic uranium shot was packed in a container tube and infiltrated with sodium to form a nuclear reactor fuel. The irradiation behavior of this fuel was observed in instrumented capsules and by post-irradiation examination. One specimen reached 0.95 at.% burnup at 1200°F with no distortion of the container or change in fuel density. Extensive sintering of the uranium particles was observed. It is believed that this occurred during a relatively short excursion to higher temperatures. In-pile measurements and out-of-pile tests both indicated that the fuel thermal conductivity remains high. A design study revealed good nuclear characteristics. Economic analysis showed the fuel to be competitive in fuel cycle cost, with potential for large savings if higher burnups can be realized. (auth)

**32156** (WAPD-262) IRRADIATION BEHAVIOR OF AUSTENITIC STAINLESS STEEL BURNABLE POISONS. R. G. Gray, W. Yeniscavich, and L. R. Lynam (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Aug. 1962. Contract AT(11-1)-Gen-14. 27p.

Irradiation testing of 1 and 1½ wt % $B^{10}$ austenitic stainless steel alloys to depletions of as high as 98% of the $B^{10}$ showed that the behavior of the alloys is consistent with a proposed model of irradiation damage in $B^{10}$ iron base alloys. The model attributes irradiation damage to the embrittlement of the alloy matrix by the transmutation of the $B^{10}$ in solid solution, to recoil of the transmutation products in the matrix from the boride particles, and to the formation of microcracks within the embrittled matrix caused by boride particle swelling. The solid volume swelling rate of the alloys was determined to be 0.33% $\Delta V$ per $10^{20}$ $B^{10}$ depletions per cc. The restraint of the Zircaloy cladding was not effective in reducing the solid volume swelling rate of the alloys, but the restraints caused anisotropic volume swelling with least dimensional change in the direction of greatest restraint. The corrosion resistance of the alloys was not noticeably reduced by irradiation, and the alloys also exhibited the ability to retain essentially all the helium gas produced during irradiation. (auth)

**32157** (AEC-tr-5375) INSTALLATIONS FOR STUDYING VARIATIONS IN THE ELECTRICAL PROPERTIES OF SEMICONDUCTORS IN A NUCLEAR RADIATION FIELD. (Ustanovki dlya Izucheniya Izmenenii Elektricheskikh Svoistv Poluprovodnikov v Pole Yadernogo Izlucheniya). G. Giants, N. Dutsesku, I. Oltyanu, and A. Dzhordzhesku. Translated from IAEA preprint No. SM-25/10 presented at the Symposium on Radiation Damages in Solids and Reactor Materials, Venice, May 7-11, 1962. 12p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 16, as abstract no. 23341.

**32158** (EURAEC-237) USE OF PLUTONIUM AS FUEL IN NUCLEAR REACTORS — IRRADIATION. Quarterly Report No. 1, December 1 to December 31, 1961. (Société Belge pour l'Industrie Nucléaire, Brussels). Jan. 1962. Work performed under United States – Euratom Joint Research and Development Program. Contract 078-61-12RDB. 20p. A translation.

Research is described which is devoted to study and perfecting of an apparatus for the out-of-pile thermal simulation of ceramic fuel units in operation, study of quality control techniques to be carried out on empty tubes and finished fuel units, and study of an apparatus for puncture tests on irradiated fuel units. (auth)

**32159** COLOR CENTERS IN A CERIUM-CONTAINING SILICATE GLASS. Jackson S. Stroud (Corning Glass Works, Corning, N. Y.). J. Chem. Phys., 37: 836-41(Aug. 15, 1962).

X-ray irradiation of glass with the weight percent composition 75% $SiO_2$, 25% $Na_2O$ produces color centers which absorb visible light. Cerium in the glass prevents the formation of these centers. The nature of the centers and the mechanism by which cerium prevents their formation are studied by measuring the optical absorption changes caused by irradiation of glasses containing small concentrations of

$Ce^{3+}$ and $Ce^{4+}$. The conclusions are: In cerium-free glass, trapped holes cause optical absorption bands with maxima near 4400 and 6200 Å. By capturing holes, $Ce^{3+}$ inhibits the formation of these two bands. The probability that a hole escapes capture by $Ce^{3+}$ is exp $(-v_3c_3)$, where $c_3$ is the $Ce^{3+}$ concentration and $v_3 = (9 \pm 2) \times 10^4$ Å$^3$. Trapped electrons cause an optical absorption band that has a maximum in the uv and that extends to 6000 Å in the visible. $Ce^{4+}$ inhibits the formation of this band by capturing electrons. (auth)

**32160** INFLUENCE OF IONIZING RADIATION ON THE ADSORPTION AND CATALYTIC PROPERTIES OF SEMICONDUCTORS. F. F. Vol'kenshteyn (Inst. of Physical Chemistry, Academy of Sciences, USSR). Kinetika i Kataliz, 2: 481-9(1961).

The effect of ionizing radiation on the adsorption and catalytic properties of semiconductors was examined in the light of the electron theory of chemisorption and catalysis. The mechanism by which the radiation influences the adsorption equilibrium, the kinetics of adsorption, and the rate of catalytic reaction is analyzed and is derived directly from the general concept of electron theory. The dependence of the radiation effect on temperature and pressure and on the history of the sample is considered. Some general laws derived from electron theory are also established. (P.C.H.)

**32161** PREPARATION OF FINELY DISPERSED METALS AND OXIDES BY IRRADIATION. G. M. Zhabrova, B. M. Kadenatsi, N. V. Zvonov, E. V. Egorov, T. S. Azizov, A. A. Batalov, V. A. Gordeeva, and P. Ya. Glazunov (Kurchatov Inst. of Atomic Energy and Inst. of Physics and Chemistry, Academy of Sciences, USSR). Kinetika i Kataliz, 3: 610-13(July-Aug. 1962). (In Russian)

In view of their sensitivity toward structural defects caused by radiation, it was deemed to be of interest to carry out topochemical processes under radiation and at low temperatures. The solid phases formed under irradiation usually possess an increased specific surface, but the subsequent sintering operations often obviate this result. However, use of low temperatures reduces the probability of sintering. This potential method of preparing highly dispersed metals and oxides was investigated on Zr, Fe, and Al hydroxides, Ni and Cu oxalates and Cu subcarbonate, exposing the materials to a flux of 0.8-Mev electrons in an accelerator and to a thermal neutron flux in the VVR-2 reactor. The temperature of the specimens during the tests did not exceed 60°C. It was found that disintegration starts at a dose above $10^8$ rad, becoming quite marked at $10^9$ to $10^{10}$ rad, resulting in the complete disintegration of the oxalates and hydroxides. Mostly metallic phases were obtained in view of the low experimental temperatures; the specific surface of the products was greatly increased, except that of $Al_2O_3$. The method might be of interest for the preparation of catalysts and chromatographic sorbents. (TTT)

**32162** EFFECT OF GAMMA RAYS ON GERMANIUM DIODES. E. M. Lobanov, V. I. Zvyagin, D. I. Blinkov, and G. B. Blinkova. Nekotorye Voprosy Priklak. Fiz., 55-7 (1961).

Gamma irradiation caused a negative photoeffect in germanium diodes. It is assumed that the effect was due to inhomogeneities in the volume (Frenkel' defects). The negative photocurrent depended on the temperature and the spectral distribution of light. It increased with increasing frequency of the illuminating light. In the photocells examined, the increase in photocurrent was particularly striking at $\lambda \approx 0.6\mu$. For waves longer than $0.8\mu$, the negative photocurrent was practically vanishing. This means that it is due to the light being absorbed by the oxide coating and not by surface-near layer. This was confirmed by a series of experiments. Gamma irradiation of germanium in moist atmosphere caused the formation of a film on the surface whose reflection coefficient was similar to that of monoxide-coated (etched) germanium. This resulted in the occurrence of the characteristic negative photocurrent. Thus, the strong change of the diode characteristics was not only due to inhomogeneities of the crystal lattice but also to the conversion of the dioxide coating into monoxide. Since surface electrons were transferred to the monoxide coating, it was assumed that it was negatively charged by applying a voltage in the blocked direction. This resulted in the formation of holes in the surface-near layer that provide a channel for excess conductivity. Light absorption transmitted the electrons from the acceptor levels to the conduction band of the coating, and from there, overcoming a potential barrier, to the volume of the germanium. The oxide coating was positively charged due to accumulation of bound holes, which reduced their concentration in the channel and, subsequently, the reverse current. Emperical formulas for the excess reverse current and for the photocurrent in a germanium diode were found. The transient characteristics of the diode were computed, experimentally verified, and graphically compared. They were found to agree fairly well. After applying a voltage, the reverse current increased, whereas it decreased when the light was turned on. (OTS)

**32163** GAMMA-INDUCED THERMOLUMINESCENCE OF QUARTZ CRYSTALS BETWEEN 100 AND 370°K. Sh. A. Vakhidov. Nekotorye Voprosy Priklad. Fiz., 79-80 1961).

The temperature dependence of the luminescence of gamma-irradiated crystals at low temperatures was measured. At temperatures of more than 100°C, quartz from different finding places show different curves of thermoluminescence. Measurements were made with strongly colored, colored, and nearly colorless quartz. The specimens were cooled to −196°C with liquid nitrogen. They were gamma-irradiated with $Co^{60}$ for 20 minutes at a dose rate of 300,000 r/hr. Subsequently, the specimen in question was heated to +100°C at a constant rate of 2.6°C per minute. Besides the high-temperature maximum, luminescence showed also a low-temperature maximum which indicated the existence of a number of shallow trapping levels. It was found that specimens assuming a color under the action of gamma-irradiation emit a more intense radiation than the colorless specimens. (OTS)

**32164** PARAMAGNETIC CENTERS IN POTASSIUM AZIDE IRRADIATED AT LOW TEMPERATURE. R. B. Horst (Univ. of Pittsburgh), J. H. Anderson, and D. E. Milligan. Phys. and Chem. Solids, 23: 157-60(Jan.-Feb. 1962). (In English)

Electron spin resonance measurements were made on single crystals of potassium azide ($KN_3$), which were irradiated and maintained at 77°K. Three types of paramagnetic centers were found. Two were identified from the hyperfine structure as consisting of an unpaired spin associated with nitrogen nuclei: the $N_2$ center and $N_4$ center. The third type appeared to be composed of unresolved hyperfine lines. The principal values and directions af principal axes of the spectroscropic (g) and magnetic hyperfine (T) splitting tensors are tabulated. Discussion is given on the interpretation of the tensors. (P.C.H.)

**32165** ELECTRON PARAMAGNETIC RESONANCE STUDIES OF $\gamma$ IRRADIATED KU-2, KU-1, SF, AND SBS

CATIONS. A. M. Semushin, I. A. Kuzin, V. V. Antuf'ev, M. P. Votinov, and V. F. Evdokimov (Leningrad Inst. of Tech.). Zhur. Fiz. Khim., 36: 1559-60(July 1962). (In Russian)

Stable free radicals were observed in dehydrated $Co^{60}$-irradiated KU-2, SF, KU-1, and SBS resins. The properties of the radicals depend on resin structure and the type of exchangeable ion. (R.V.J.)

**32166** RADIATION EFFECTS ON TRANSISTORIZED POWER CONVERTERS. P. A. Trimmer (Diamond Ordnance Fuze Labs., Washington, D. C.). Preprint Paper No. CP 62-1192. New York, American Institute of Electrical Engineers, 1962. 10p. $1.00.

Two types of transistorized power converters, common emitter and common base, were exposed to pulsed neutron radiation at the Diamond Ordnance Radiation Facility, a TRIGA Mark F reactor. Permanent damage data were obtained for time integrated fast neutron fluxes from $2.2 \times 10^{12}$ to $2.6 \times 10^{14}$ neutrons/cm$^2$. It was found that proper operation could be maintained by adjustment of the bias and feedback currents with an accompanying loss in efficiency. Both design types performed equally well. The results of these tests are discussed along with the selection of transistors for use in power converters that must survive in a radiation environment. A brief description of the radiation facility is also given. (auth)

# PHYSICS

## General and Miscellaneous

*Refer also to abstracts 31696, 31726, 31727, 31728, 31730, 31731, 31879, 32066, 32068, 32069, 32070, and 32075.*

**32167** (62-RL-2960E) A PULSED 100-KILOWATT, 10-MEGACYCLE R-F OSCILLATOR. P. C. Noble and H. Hurwitz, Jr. (General Electric Co. Research Lab., Schenectady, N. Y.). Feb. 1962. 17p.

A pulsed 100-kw r-f oscillator operating in the 10-megacycle range has been designed and constructed for use in plasma physics experiments. The oscillator is designed to work into a variable impedance load and to use GE Type 6251 Class B television amplifier tubes. With some modification the design could probably be extended to output powers of the order of 0.5 Mw. (auth)

**32168** (AD-272156) FEW CENTRE SCATTERING CALCULATIONS. I. PHYSICAL FORMULATIONS OF VARIATIONAL TREATMENTS OF ELECTRONIC EXCITATION OF FEW-CENTRE MOLECULES BY SLOW ELECTRON SCATTERING. Technical Note No. 2. L. A. Edelstein (London. Univ., University Coll.). Oct. 19, 1961. Contract AF61(052)-257. 19p.

At present there are no theoretical methods of calculating cross sections for electronic excitation of small molecules by slow electrons unless the molecule is diatomic or approximately spherical. A number of procedures suitable for use with the Hulthens or Kohn variational methods and for few-center molecules are formulated, and a new expansion theorem is derived. The static centroidal method is the most promising of those examined. (auth)

**32169** (AD-272849) HEAT DIODE CONVERTER. Interim Scientific Report No. 3, November 1, 1962 to January 31, 1962. (Westinghouse Electric Corp. Research Labs., Pittsburgh). Feb. 20, 1962. Contract AF33(616)-8262. 31p.

Activities in a program of theoretical and experimental studies concerning the characteristics of the plasma and cathode of a thermionic converter are reported. During the report period, efforts were devoted largely toward development of various test vehicles. The remaining contract time will be devoted to research on cathode characteristics, especially their interaction with Cs vapor. Data and information obtained in research on current voltage characteristics of a Mo cathode in variable spacing Cs cells are given. Other research is reported on thermionic emission from materials in Cs vapor, evaporation of Mo in presence of Cs vapor, electron reflection from Cs-coated surfaces, and Cs vapor thermal conductivity. (J.R.D.)

**32170** (AECL-1572) DETERMINATION OF POLARIZATION VECTORS FROM NEUTRON GROUP INTENSITIES. B. N. Brockhouse, L. N. Becka, K. R. Rao, and A. D. B. Woods (Atomic Energy of Canada Ltd., Chalk River, Ont.). [1962]. 25p.

The constant Q method for measuring the neutron groups produced in one-phonon scattering offers promise of obtaining intensities sufficiently accurate to permit experimental determination of the polarization vectors of the normal modes and hence of the interatomic forces in the crystal. Experiments on sodium were carried out to determine the polarization vectors of modes at several off-symmetry positions in a (110) plane. The polarization vector directions, good to about 3°, were in satisfactory agreement with vectors calculated from a force constant model deduced from the results in symmetry directions. Experiments were carried out on germanium in which the line intensities of 22 selected neutron groups, corresponding to modes for which the polarization vectors are fixed by symmetry, were studied. When corrected for the various specific factors (frequency, wave vector transfer Q, population factor etc.) involved, the intensities showed a residual disagreement (R-factor) of 7.3%. From measurements of the intensities of groups corresponding to transverse acoustic vibrations in [111] directions, it was deduced that the two atoms in an appropriately defined primitive unit cell move practically in phase for all wavelengths. Correspondingly, for transverse optic modes the two atoms move 180° out of phase. (auth)

**32171** (AECL-1574) THE TEMPERATURE DEPENDENCE OF SOME NORMAL MODES IN STRONTIUM TITANATE. R. A. Cowley (Atomic Energy of Canada Ltd., Chalk River, Ont.). [1962]. 15p.

The frequency wave vector dispersion curves were measured for some of the normal modes in strontium titanate along [100]. The experiments were performed using a triple axis crystal spectrometer and the constant Q technique. Of particular interest is the temperature dependence of the lowest transverse optical branch, which was studied at two temperatures. The frequencies (units $10^{12}$ c/s) at $q = 0$ are $1.27 \pm 0.05$ at 90°K and $2.73 \pm 0.05$ at 296°K. The dispersion curves have maximum frequencies (4.2 at 90°K, 4.4 at 296°K) near the middle of the zone; at the zone boundary the frequencies are about 3.5. The anomalous temperature dependence of the $q = 0$ mode was predicted by Cochran, and the magnitude of the change with temperature, which may be obtained from the temperature dependence of the dielectric constant, is in good agreement with the theory. The non-infrared active mode was observed and has a frequency at $q = 0$ of $7.95 \pm 0.15$. (auth)

**32172** (NBS-Mon-50) BIBLIOGRAPHY ON ATOMIC TRANSITION PROBABILITIES. B. M. Glennon and W. L. Wiese (National Bureau of Standards, Washington, D. C.). Aug. 1, 1962. 43p.

A bibliography on atomic transition probabilities is presented. The papers are arranged according to elements and stages of ionization, and the method employed and class of transitions are indicated behind each reference. Only articles on discrete transitions, both permitted and forbidden, are listed. Also included is a supplementary list of papers dealing with transition probabilities from a general point of view, a table showing the availability of numerical material on the individual atoms and ions, and a table of conversion factors. (auth)

**32173** (NP-12052) FORMATION OF $SF_6^-$ BY INELASTICALLY SCATTERED ELECTRONS. Technical Report No. 14. Scientific Paper 62-928-113-P1. R. K. Curran (Westinghouse Electric Corp. Research Labs., Pittsburgh). July 27, 1962. Contract NONR 2584(00). 5p.

A mass spectrometer ion source was used in an experiment demonstrating the possibility of observing electrons that have undergone inelastic collisions and lost essentially all of their energy. The experiment was performed in $SF_6^-$ mixtures and $N_2$ mixtures. The results agree with those obtained by other workers. (J.R.D.)

**32174** (ORNL-1339) ELECTROMAGNETIC RESEARCH DIVISION QUARTERLY PROGRESS REPORT, PART I FOR PERIOD ENDING MARCH 31, 1952. F. T. Howard, ed. (Oak Ridge National Lab., Y-12 Area, Tenn.). Aug. 27, 1952. Contract W-7405-eng-26. 30p.

Relocation of the ion source in the 86-in. cyclotron increased the available beam energy substantially. Modifications were also made to permit the use of 100 $in.^2$ targets. Proton currents of 1 ma can now be obtained at ~24 Mev. The 63-in. cyclotron was completely assembled and checked. In r-f tests, a 75-kv dee-to-dee voltage was maintained under vacuum for long periods without evidences of failures, thus exceeding the 60-kv design specification. In an investigation of proton beam distribution on the 22-in. cyclotron, it was shown that most of the proton loss from the beam occurs within one-half of the maximum radius. The ratio of $H_3^+$ to $H_1^+$ ions in the beam increases at lower arc intensities in the ion source. Accelerated corrosion was found in an Inconel tube containing #14 eutectic (ARE) after a six-hour bombardment with 20-Mev protons at 4500 watts/$cm^3$. Installation of facilities for the preparation of Pu isotopes is nearing completion; preliminary tests are being made. (auth)

**32175** (ORNL-1531) ELECTROMAGNETIC RESEARCH DIVISION SEMIANNUAL PROGRESS REPORT FOR PERIOD ENDING MARCH 20, 1953. F. T. Howard, ed. (Oak Ridge National Lab., Tenn.). June 8, 1953. Contract W-7405-eng-26. 27p.

A number of new reactions, some of them of a nuclear-fusion type, were observed in the 63-in. N cyclotron. Angular distributions of particles produced in nuclear reactions were measured extensively with the internal beam of the 86-in. cyclotron. Trial production of a number of radioisotopes in this cyclotron revealed that significant reductions in the cost of cyclotron-produced isotopes can be expected. New techniques are being developed which will contribute to the plans for the deflection of the beam of the 86-in. cyclotron. Preliminary design studies were made for a variable-energy cyclotron and for an 80-Mev heavy-particle cyclotron. The program for the separation of Pu isotopes has advanced to the point where it is clear that such separation is feasible. A study program involving small package-type reactors was started. (auth)

**32176** (PR-P-53) PHYSICS DIVISION PROGRESS REPORT, JANUARY 1 TO MARCH 31, 1962. (Atomic Energy of Canada Ltd., Chalk River, Ont.). 82p. (AECL-1542)

During the past two years well-defined high velocity heavy ion beams have received increased attention as tools in nuclear structure studies. In order to assess the heavy ion energies that may be achieved with a proposed tandem accelerator, it is necessary to know how many electrons can be stripped from energetic heavy ions. For this reason measurements were made of the charge distribution of $F^{19}$, $Cl^{35}$, and $Br^{79}$ ions which were passed through a thin C stripping foil at 10 to 40 Mev. It is found, for example, that at 15 Mev a good yield of $Br^{79}$ ions of charge 13 is obtained. Thus a machine with 15-Mv terminal voltage and one stripping foil would provide a copious beam of 210-Mev $Br^{79}$ ions. By using a second stripping foil, useful beams at energies up to 300 Mev would be obtained. The corresponding maximum energy for Cl is 230 Mev and for F, it is 150 Mev. The Br ions would initiate nuclear reactions with elements up to Xe, and the Cl and F would produce nuclear reactions with all elements. The solar particle events of Nov. 15, 1960, and of July 20, 1961, were further analyzed. The characteristics of both these events strongly support the hypothesis that in planetary space large loops of magnetic flux are dragged out from the vicinity of sunspots by the solar plasma. In the Nov. 12, 1960, event the earth seemed to be initially outside a magnetic bottle formed by such lines of magnetic force at the time of emission of a burst of fast protons from the sunspot, and was subsequently enveloped by the cloud and subjected to the full intensity of the bottled protons. The interpretation of these events with the Deep River neutron monitor observations is now generally accepted as valid. For many years it was believed that the low-lying excited states of a system of aligned magnetic moments (a ferromagnetic or antiferromagnetic crystal) are spin waves, wave-like magnetic disturbances somewhat similar to the lattice waves in crystals. A few years ago neutron scattering studies gave a direct demonstration of the existence of long wavelength acoustic spin waves in magnetite. Additional measurements demonstrated the existence of short wavelength spin waves, including an optical branch in which magnetic moments on different sublattices move in opposite phases. From the measurements the interactions between the magnetic moments can be deduced. In connection with classical physical situations and standard mathematical functions, problems of computation constantly arise. New computational methods, applicable in such domains of the parameters, have accordingly been developed and tested. In many reactor operation and development problems requiring numerical answers the use of diffusion theory is justified in predominantly scattering media provided it is supplemented by boundary conditions supplied by transport theory. A boundary condition frequently required is that at the interface of the scattering medium with a strong absorber. This can be expressed in terms of the blackness of the absorber, or medium enclosed by the boundary, the fraction, that is, absorbed of all neutrons incident on the boundary. The nature of the boundary condition for unit blackness, that is for a perfect absorber, and for various geometrical forms of the boundary was an early subject of study. Such studies were since extended to other absorbers and have now a considerable development. The ranges of validity of approximations useful under various conditions were examined and computational methods were developed. The shell model of the nucleus is often used to correlate and interpret the experimental data on the low-lying states of nuclei. For example, the low-lying even parity states of nuclei with atomic number in the range $16 < A < 40$ were largely explained on the basis of this model with quite general assumptions about the nature of the nuclear forces and the symmetry properties of the states. An attempt is now being made to carry out a similar classification of the low-lying odd parity states. In the case of $O^{16}$ such a classification was found possible, thus leading to the prediction of the properties of low-lying levels in $O^{18}$. A qualitative explanation of the levels of $Ne^{20}$ was also made. (auth)

**32177** (UCRL-10349) PHYSICS DIVISION SEMIANNUAL REPORT, NOVEMBER 1961 THROUGH APRIL 1962. (California. Univ., Berkeley. Lawrence Radiation Lab.). May 17, 1962. Contract W-7405-eng-48. 80p.

A large part of the research with bubble chambers was devoted to the operation of the separated high-energy $K^-$ beam and analysis of the resulting data. Details of experiments in this area are given along with work on data reduction, bubble chamber development, and superconductivity studies for development of high-field magnets. Research on the decay modes of $\Sigma$ hyperons is reported along with other strange-particle investigations and heavy ion research. Development work on a video track analyzer was continued. Work on the S-matrix theory is described in published reports along with various applications of the S-matrix theory. Work on theoretical plasma physics is summarized along

with work on atomic physics, particle accelerators, and nuclear physics. The work in the mathematics and computing group was devoted to program development for bubble chamber data analysis and several miscellaneous mathematical programming developments. Work in physics research is reported on $K^+$-proton interactions, $\pi$-$\pi$ interactions, phase shift analysis of $\pi$-p scattering, pion-proton interactions, properties of radioisotopes, and other research projects. Data analysis by the FOG program is reported along with development of the CLOUDY program and the FAIR program. Continued research on single meson production in $\pi$ + p collisions is reported. A summary of work is also included on the 184-in. cyclotron and the 60-in. cyclotron. (J.R.D.)

**32178** (AEC-tr-5355) CALCULATION OF ALTERNATING CURRENT CORONA CHARACTERISTICS. G. N. Aleksandrov. Translated by Helen Basil (Argonne National Lab., Ill.) from Zhur. Tekh. Fiz., 25: 1804-16(1955). 19p.

A method is described for the calculation of a-c corona characteristics, using an arbitrary voltage curve, which is applicable to various corona systems, including the three-phase system. Calculated results are compared to experimental data. (auth)

**32179** (UCRL-Trans-858(L)) LIGHT CHARACTERISTICS OF THE PHOSPHOR $Cd_2P_2O_7$-Mn,Pb. N. A. Gorbacheva. Translated by Sergey Shewchuck (Univ. of California, Lawrence Radiation Lab., Berkeley) from Zhur. Eksptl'. i teoret. Fiz., 21: 305-9(1951). 9p.

The occurrence of a flash in $Cd_2P_2O_7$ (cadmium pyrophosphate) with Mn and Pb activators at the moment of excitation by light was investigated. Results indicate that the system of localization levels of the double activator (Mn + Pb) cannot be presented in the form of a sum (or linear combination) like the localization levels of the single-activators. This confirms the opinion that the activators are found in strong interaction between themselves. The disappearance or severe weakening in the double-activator phosphor of the localization levels, explained by Mn and Pb, during simultaneous formation of new levels indicates the formation of two complex centers of lumination which contain both Mn and Pb simultaneously, similar to the way that this takes place in alkaline-earth phosphors with two rare-earth activators. (J.R.D.)

**32180** HOMOGENEOUS VARIATIONAL PRINCIPLE WITH THIRD ORDER DERIVATIVES IN THE SPECIAL THEORY OF RELATIVITY. Z. Borelowski (Jagellonian Univ., Krakow). Acta Phys. Polon., 21: 609-35(1962). (In English)

The present investigation deals with motion of a free particle in Minkowski space (with velocity both smaller than and equal to that of light) as determined by the homogeneous variational principle $\sigma \int_{\pi_1}^{\pi_2} L D\pi = 0$, wherein the Lagrangian L of the particle depends on derivatives with respect to $\pi$ up to order three inclusively. Such a particle will be referred to as a particle of order three. $\pi$ is an arbitrary parameter which, in the case of light velocity, will be assumed as being the time $t$, and in that of velocity lesser than that of light — as being the proper time $\tau$. The Lagrangian L is required to be independent of the $x^\alpha$, to assume neither zero nor infinite value for light velocity, and to be a scalar. The integral $\int_{\pi_1}^{\pi_2} LD\pi$ is required to be invariant with respect to change of parametrization. From the solutions of the equations of motion as obtained from this variational principle and relating to the case of velocity smaller than that of light, the Lagrangian L shall become for them a first integral of the equations of motion (for $\pi = \tau$). It is found that, in setting up the Lagrangian, an auxiliary condition is introduced (which can be isoperimetrized) which, for light velocity, is fulfilled automatically. On assuming the energy and momentum four-vector of the particle to be time-like, there is denoted by $\Sigma_0$ the inertial reference system in which the spatial coordinates of this four-vector vanish. Applying an appropriately modified generalized canonical Ostrogradski-Hamilton formalism, it is shown that the particle of order three is a spin particle and moves along a circle in $\Sigma_0$. Its spin is constant, and the spin vector is perpendicular to the plane of its path in this system of reference. For velocity equal to that of light, the radius of the circle is a function of the spin of the particle and of three constants: a multiplicative constant $\gamma$ (having the dimension of a mass), the constant $l_0$ (having that of a length), and a dimensionless constant $\eta$. For velocity lesser than that of light, the particle moves in $\Sigma_0$ with constant velocity $v = v_0$ and the radius of the circle depends on $v_0$, $l_0$, and $\eta$; albeit, in general, several values of $v_0$ and hence several different motions of the particle can correspond to one value of the spin. For this reason, it would seem that a particle of order three considered jointly with its path in the system is not adapted for direct physical interpretation. (auth)

**32181** AXIOMATIC DEDUCTION OF THE GENERAL LORENTZ TRANSFORMATIONS. H. M. Schwartz (Univ. of Arkansas, Fayetteville). Am. J. Phys., 30: 697-707 (Oct. 1962).

The general Lorentz transformations are derived on the basis of a set of postulates that are fully consistent with the underlying ideas of Newtonian mechanics, but which do not include the independent postulate of absolute simultaneity. Thus, the assumption of the constancy of the vacuum speed of light c is not introduced as a starting point. Instead, the given development leads to a universal critical velocity, and the two alternatives assuming this velocity of infinite or finite correspond to Newtonian and relativistic kinematics respectively, with the critical velocity identified with the experimental value c in the latter case. (auth)

**32182** "META" RELATIVITY. O. M. P. Bilaniuk, V. K. Deshpande, and E. C. G. Sudarshan (Univ. of Rochester, N. Y.). Am. J. Phys., 30: 718-23(Oct. 1962).

The hypothesis that a particle may move faster than the velocity of light in vacuo is examined in the framework of the classical (nonquantum) theory of special relativity. (auth)

**32183** ELECTRON LEVELS, ELECTROCHEMICAL EFFECTS, AND THERMOELECTRICITY. William T. Scott (Univ. of Nevada, Reno). Am. J. Phys., 30: 727-37 (Oct. 1962).

The concepts of cavity potential (electrostatic potential in a cavity in a conductor) and Fermi potential (energy per unit charge for an electron at the Fermi level) are defined and used to discuss the work function, contact potentials, Ohm's law, electrode-solution equilibria, and chemical emf's. With the introduction of the entropy transport per unit charge for electrons in a metal, the Seebeck, Peltier, and Thomson effects are elucidated, and the fact that no emf exists at a thermal junction is made clear. Certain other confused points are cleared up. (auth)

**32184** MECHANICAL CONSERVATION LAWS AND THE PHYSICAL PROPERTIES OF GROUPS OF MOTIONS IN FLAT AND CURVED SPACE-TIMES. William R. Davis and Gerald H. Katzin (North Carolina State Coll., Raleigh). Am. J. Phys., 30: 750-64(Oct. 1962).

The intimate relation of symmetry properties describable

by groups of motions and the consequent conservation laws realizable for a particle in classical mechanics and in the mechanics of restricted and general theories of relativity are discussed, using elementary results of the theory of continuous groups. In addition, for the case of special relativistic mechanics the finite form of the groups of motions, underlying all of the possible constants of the motion of the form of first integrals linear in the momenta, is constructed and shown to be the inhomogeneous (i.e., including displacements) proper Lorentz transformations. (auth)

**32185** THE INTERACTION OF IONIC BEAMS WITH SOLID SURFACES. Walter J. Moore, Cormac D. O'Briain, and Amelie Lindner (Indiana Univ., Bloomington). Ann. N. Y. Acad. Sci. 67: 600-18(May 24, 1957).

The criteria for valid quantitative studies of sputtering are outlined, and it is pointed out that most of the previous work on sputtering did not satisfy the criteria. A r-f ion source for producing hydrogen ions and its performance is described. The design of an apparatus for studying ion-solid interactions and the experimental procedures used in studying the sputtering of silver are described in detail. Preliminary results for the sputtering coefficients $\theta$ at 9.25 kv are reported: For the $H^+$ ion on mat surface silver, $\theta = 0.032 \pm 0.002$; on bright silver, $\theta = 0.025 \pm 0.001$. For the $H_2^+$ ion on bright silver, $\theta = 0.065 \pm 0.002$, and for the $D^+$ ion, $\theta = 0.072 \pm 0.001$. These values are believed to be more accurate than the higher values reported by previous workers. (D.L.C.)

**32186** A METHOD TO MEASURE THE EFFECTIVE CROSS SECTIONS FOR CHARGE EXCHANGE. J. Steyaert, J. Bouchat, and J. M. Delfosse. Ann. soc. sci. Bruxelles. Ser. I, 75: 188-90[1961]. (In French)

The effective cross sections for the charge exchange of $H_2$ and H were measured by the current attenuation method using a double focusing mass spectrograph. The experimental setup is illustrated and the results obtained are shown graphically. In the case of H the values obtained were lower than those reported by previous investigators. The value for $H_2$ is in better agreement with those of other authors. The method is simple, but the absolute measurement is not precise. (J.S.R.)

**32187** WAVENUMBER REPRODUCIBILITY OF THE RADIATION $2p_{10}$-$5d_5$ OF KRYPTON 86. C. F. Bruce and R. M. Hill (Commonwealth Scientific and Industrial Research Organization, Chippendale, New South Wales, Australia). Australian J. Phys., 15: 152-61(June 1962).

The vacuum wavenumber of the radiation $2p_{10}$-$5d_5$ (6056 Å) of krypton-86 emitted by a hot cathode Engelhardt-type discharge lamp was established for the temperature range 58–70°K and current density range 0–1.0 amp/cm$^2$. Wavenumbers relative to the value for the unperturbed state of the radiation were measured with a reliability of 1 part in $10^9$ using a photoelectric recording and electromechanical scanning Fabry-Perot interferometer. However, this reproducibility is not possible for different lamps without a more exact specification for the form and operation of the lamp and for the interferometric system used. With the present international specification for the lamp, the reproducibility of this new primary standard of length is better than 1 part in $10^8$. (auth)

**32188** PRINCIPLES OF RESTRICTED RELATIVITY AND THE GENERAL LORENTZ TRANSFORMATION. S. Kichenassamy (Institut Henri Poincaré, Paris). Bol. univ. Paraná, fís. teorica, No. 2, 11p. (Nov. 1961). (In Portuguese)

The general Lorentz transformation is deduced which permits the coordinates of one event to be related to two reference systems, one moving rectilinearly and uniformly with respect to the other. The particular interest of this work is in the systematic use of a tensor formalism, which permits the principle of reciprocity to be clearly exposed. (J.S.R.)

**32189** THE SHOT EFFECT AND NOISE OF GAS DISCHARGES IN ELEMENTARY TREATMENT. F. Luedi (Brown, Boveri & Cie., Baden, Switzerland). Helv. Phys. Acta, 35: 220-8(1962). (In German)

The Schottky method for investigating the shot-effect (representation of each individual event by means of Fourier series and incoherent summation of the squares of the amplitudes of all preceding events) is used in a study of gas-discharge noise. For dense gases this treatment yields the Nyquist equation (thermal noise); for thin gases it yields a shot equation similar to the diode-noise equation. (tr-auth)

**32190** ELECTROCONDUCTING FLUID FLOW IN LINEAR CURRENT MAGNETIC FIELD. E. P. Zimin (Inst. of Power Engineering, Academy of Sciences, USSR). Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk, Mekham. i Mashinostr., No. 3, 15-18(May-June 1962). (In Russian)

A precise solution was found for a system of equations that describe the field temperature and velocity in laminar conducting fluid flow in an annular channel with linear azimuthal field. The magnetic Reynold's number is $R \ll 1$. (tr-auth)

**32191** MÖSSBAUER EFFECT IN IRON(III) ACETYLACETONATE AND CHEMICAL CONSEQUENCES OF K CAPTURE IN COBALT(III) ACETYLACETONATE. G. K. Wertheim (Bell Telephone Labs., Inc., Murray Hill, N. J.), W. R. Kingston, and R. H. Herber. J. Chem. Phys., 37: 687-90(Aug. 15, 1962).

The resonance absorption of 14.4-kev gamma rays in $Fe^{57}$ (Mössbauer effect) was observed in Fe(III) and Co(III) acetylacetonate, the former used as an absorber against a source of $Co^{57}$ diffused into metallic chromium, the latter as a $Co^{57}$ labeled source against an $K_4Fe(CN)_6$ (38%$Fe^{57}$) absorber. The Fe(III) acetylacetonate absorber spectrum shows a single broad line ($\Gamma_{\frac{1}{2}} = 1.83 \pm 0.09$ mm-sec$^{-1}$) with an isomer shift of $0.50 \pm 0.09$ mm-sec$^{-1}$. The Co(III) acetylacetonate source shows a complex spectrum which can be resolved into a single peak assigned to Fe(III) and a quadrupole split pair of lines assigned to Fe(II). These data are interpreted in terms of the chemical consequences following K capture in $Co^{57}$ and suggest a twofold preference for the stabilization of the higher charge state in the Co(III) acetylacetonate matrix. No evidence for ionic charge states higher than 3+ is observed, and it is assumed that these species – if formed as a consequence of the prior nuclear event – have been reduced to the observed states in times short compared to $10^{-7}$ sec. (auth)

**32192** EQUATION OF STATE OF CLASSICAL HARD SPHERES AT HIGH DENSITY. Z. W. Salsburg (Rice Univ., Houston, Tex.) and W. W. Wood. J. Chem. Phys., 37: 798-804(Aug. 15, 1962).

Under certain conditions, an asymptotic expression for the equation of state of a classical mechanical system of N $\nu$-dimensional ($\nu = 1$, 2, or 3) hard spheres confined in a volume V is obtained in the form $[(pV)/(NkT) = (\nu(1 - 1/N))/((V/V_0) - 1) + O(1)]$. This expression agrees with the leading term in $V/V_0 - 1$ of the usual free-volume approximation for $N = \infty$. The conditions under which this conclusion is established are a restriction to a finite number of molecules N with periodic boundary conditions, and the requirement that as $V \to V_0$ the accessible configuration states approach a close-packed configuration whose coor-

dination number c satisfies the requirement $c \geq 2\nu - 2(\nu - 1)/N$. Such a limiting configuration, from which only an infinitesimal region of configuration space is accessible under an infinitesimal expansion, is called a stable configuration; the above restriction on the coordination number is a necessary condition for stability. The difficulties which appear as $N \to \infty$ are indicated. (auth)

**32193** REFLECTION AND DISSOCIATION OF $H_2$ ON TUNGSTEN. Joe N. Smith, Jr. and Wade L. Fite (General Atomic Div., General Dynamics Corp., San Diego, Calif.). J. Chem. Phys., 37: 898-904(Aug. 15, 1962).

Through the use of modulated atomic beam techniques, the reflection and dissociation of $H_2$ at a tungsten surface above 2500°K was studied. Two experimental configurations were employed. In the first configuration, a collimated beam of molecular hydrogen was directed at the tungsten surface, and the angular distribution of particles evaporating from the surface was examined mass spectrometrically. In the second configuration, the tungsten test surface was located in the first of three differentially pumped vacuum chambers. $H_2$ was admitted into this chamber, thereby providing an isotropic source of incident particles. Particles evaporating from the surface were collimated and examined mass spectrometrically in the third chamber. From these experiments it is observed that at high temperatures the angular distribution of atomic hydrogen evaporating from the target surface obeys the cosine law. However, the angular distribution of reflected $H_2$ displays a shift toward the specular ray. Above 2500°K the sticking probability of $H_2$ on tungsten approaches a limiting value of 0.3. (auth)

**32194** MOLTEN SALT SOLUTIONS OF ELECTROPOSITIVE METALS: ELECTRONIC CONDUCTANCE AND METAL HALIDE STOICHIOMETRY. M. A. Bredig (Oak Ridge National Lab., Tenn.). J. Chem. Phys., 37: 914-15(Aug. 15, 1962).

It is possible to correlate semiquantitatively the electronic conductance of solutions of electropositive metals in their molten halides where deep electron traps are not significant. A plot of the electronic conductance vs $N_M/z$, where $N_M$ = the mole fraction of the metal and z = the valence of the metal, shows similarity for KCl–K, $LaCl_3$–La, and $CeCl_3$–Ce. The deviation of the $SrCl_2$–Sr curve from the other curves might be due to trapping of some electrons in $Sr_2^{2+}$ or $Sr^+$ ions. (D.L.C.)

**32195** REDUCTION OF OPERATOR RINGS AND THE IRREDUCIBILITY AXIOM IN QUANTUM FIELD THEORY. Thomas F. Jordan and E. C. G. Sudarshan (Univ. of Rochester, N. Y.). J. Math. Phys., 3: 587-94(July-Aug. 1962). (NYO-10032)

The mathematical theory of the reduction of operator rings is used to investigate some structures that can occur in quantum field theory when the postulate that the field operators generate an irreducible ring is relaxed. In particular, it is shown that if a quantum field theory has a commutator that commutes with all field operators it is a direct integral of theories, in each of which the commutator is a scalar. If in addition the theory satisfies the postulates of Lorentz covariance, existence of an invariant vacuum, and mass and energy spectra, then the the theory is a direct integral of generalized free field theories, whenever the unitary representation of the Lorentz group can be constructed in terms of functions of the field operators and every state can be constructed by applying field operators on the vacuum. It is also shown that the latter two assumptions together with the requirement of a unique invariant vacuum state are sufficient to prove that the ring generated by the field operators is irreducible. In other words, under these conditions the irreducibility postulate is redundant. (auth)

**32196** SINGULARITIES OF THE SECOND TYPE. D. B. Fairlie (Cambridge Univ., Eng.), P. V. Landshoff, J. Nuttall, and J. C. Polkinghorne. J. Math. Phys., 3: 594-602(July-Aug. 1962).

A class of singularities associated with Landau-Cutkosky diagrams is investigated. The singularities correspond to solutions of the Landau equations with infinite internal momenta. Some of the properties of these singularities depend on the spins of the participating particles. It is shown that a subset of these singularities, called pure second-type singularities, does not appear on the physical sheet. (auth)

**32197** ON FORCES AND INTERACTIONS BETWEEN FIELDS. Dave Pandres, Jr. (Martin Co., Denver). J. Math. Phys., 3: 602-7(July-Aug. 1962).

After a discussion of certain properties of multivalued functions is given, these functions are used to give a scalar representation of electromagnetic theory. In this representation, the four-vector potential A appears as the four-gradient of a multivalued function $\phi$. The problem of solving the time-dependent Schrödinger equation for a particle of charge $\underline{e}$ in an electromagnetic field is equivalent to the problem of solving the corresponding field-free equation in a space of multivalued functions $\overline{\psi}$, which is connected to the space of single-valued functions $\psi$ by the relation $\overline{\psi} = U\psi$ where $U = \exp(-ie\phi)$. Further, if $L_0(\overline{\psi}, A)$ is the Lagrangian for a noninteracting particle field $\overline{\psi}$ and photon field A, then $L_0(U\psi, A)$, regarded as a functional of $\psi$ rather than $\overline{\psi}$, is the Lagrangian for interacting fields $\psi$ and A. This result suggests that other interactions (e.g., strong and weak interactions) should be introduced by using a transformation T that is more general than U. More fundamental reasons for believing that this is the case arise when multivalued coordinate transformations are considered. It is shown that any curved Riemannian space may be connected with a flat space by a multivalued coordinate transformation. This is possible because the metric transforms like a tensor under these transformations, but the Riemann curvature symbol does not. If the equations of motion of a free, classical, relativistic particle are written in flat-space coordinates and the equations are assumed to transform covariantly under multivalued coordinate transformations (this is a natural generalization of the equivalence principle), equations of motion in the curved-space coordinates are found that describe a particle in a gravitational and electromagnetic field. Unfortunately, however, the electromagnetic field at any point of space-time depends on the four-velocity of the test particle at that point. This defect, together with the existence of essentially quantum-mechanical forces and the fact that the uncertainty principle prevents velocity measurements from being made when position is measured exactly, suggests that the Klein-Gordon (or Dirac) equation for a free particle should be written in flat-space coordinates, followed by a change of independent variables into curved-space coordinates. When this is done, it is seen that a corresponding change of dependent variable $\overline{\psi} = T\psi$ is required in order that the curved-space wave function be a single-valued function of the curved-space coordinates. The fully transformed equation describes a particle in a gravitational and electromagnetic field as well as certain other fields whose properties are not fully understood. (auth)

**32198** RENORMALIZATION OF A CLASSICAL GRAVITATIONAL FIELD INTERACTING WITH QUANTIZED MATTER FIELDS. Ryoyu Utiyama and Bryce S. DeWitt

(Univ. of North Carolina, Chapel Hill). J. Math. Phys., 3: 608-18(July-Aug. 1962).

The behavior of the mean value of the energy-momentum tensor of a set of quantized matter fields interacting with a classical gravitational field, which is, in turn, produced by this mean value is investigated. Singularities appear in the energy-momentum tensor corresponding to divergences of three different orders: $\infty^4$, $\infty^2$, and $\log \infty$. These can be removed by the introduction of counter terms into Einstein's equation. The $\infty^4$ singularity is removed by a "cosmological term," the $\infty^2$ singularity by a renormalization of the gravitation constant, and the $\log \infty$ singularity by a counter term derivable from a Lagrangian that is quadratic in the Riemann tensor. The gravitational Green's function corresponding to this semiclassical approximation fo the fully quantized theory is found to have the asymptotic behavior $1/p^4$ instead of $1/p^2$, and thus to have a much weaker singularity in the coordinate representation than the Green's function of the "bare" linearized theory. (auth)

**32199** DEFINITION OF COMMUTATORS VIA THE UNCERTAINTY PRINCIPLE. Bryce S. DeWitt (Univ. of North Carolina, Chapel Hill). J. Math. Phys., 3: 619-24(July-Aug. 1962).

A general demonstration is given of the fact that the quantization of any system, as expressed by the uncertainty principle, implies the quantization of all other systems to which it can be coupled. It is also shown that the precise form that the uncertainty principle takes is uniquely specified. That is to say, the uncertainty principle effectively defines the commutator of any pair of observables. The argument serves to detach completely from its canonical origins a certain definition of the commutator (a generalization of one given by Peierls) applicable to systems with infinite-dimensional invariance groups, for which the identification of canonical variables is an inconvenience. The measurements of a single observable and of a pair of observables are analyzed according to the Bohr-Rosenfeld scheme. (auth)

**32200** QUANTIZATION OF FIELDS WITH INFINITE-DIMENSIONAL INVARIANCE GROUPS. II. ANTICOMMUTING FIELDS. Bryce S. DeWitt (Univ. of North Carolina, Chapel Hill). J. Math. Phys., 3: 625-36(July-Aug. 1962).

The Green's function approach to the definition of commutators for fields possessing infinite-dimensional invariance groups is extended to the case of anticommuting fields. The discussion is restricted to fields that provide linear homogeneous or inhomogeneous representations of the group, a restriction that excludes no case of practical interest and facilitates setting up the formalism in a manifestly covariant way. Self-consistency of supplementary conditions, Huygens' principle, and reciprocity relations are established just as for commuting fields. Careful attention must be paid to the ordering of anticommuting factors, particularly in the demonstration of the Poisson-Jacobi identity. The invariance properties of the Poisson bracket are investigated in detail and the notion of conditional invariant is introduced. A special class of conditional invariants called asymptotic invariants, which give a complete physical characterization of initial and final states of the dynamical system, is studied. (auth)

**32201** THE SPIN-STATISTICS THEOREM. R. Arnowitt (Syracuse Univ., N. Y.) and S. Deser. J. Math. Phys., 3: 637-49(July-Aug. 1962).

A derivation of the connection between spin and statistics is obtained for spin 0, ½, and 1 fields with arbitrary local interactions. The basis used is the Schwinger actior principle, whose assumptions are specified; these assumptions include neither positive energy spectrum nor TCP invariance. The connection can be obtained without either of these two extra requirements in most cases. The remaining cases are characterized by non-TCP invariant free Lagrangians and nonpositive definite free-particle energies. Commutation relations among different fields are also briefly discussed by means of the action principle. (auth)

**32202** ORDERING ENERGY LEVELS OF INTERACTING SPIN SYSTEMS. Elliott Lieb and Daniel Mattis (International Business Machines Corp., Yorktown Heights, N. Y.). J. Math. Phys., 3: 749-51(July-Aug. 1962).

The total spin S is a good quantum number in problems of interacting spins. It is shown that for rather general antiferromagnetic or ferrimagnetic Hamiltonians, which need not exhibit translational invariance, the lowest energy eigenvalue for each value of S [denoted E(S)] is ordered in a natural way. In antiferromagnetism, $E(S + 1) > E(S)$ for $S \geq 0$. In ferrimagnetism, $E(S + 1) > E(S)$ for $S \geq \mathscr{I}$, and in addition the ground state belongs to $S \leq \mathscr{I}$. $\mathscr{I}$ is defined as follows: Let the maximum spin of the A sublattice be $S_A$ and of the B sublattice $S_B$; then $\mathscr{I} \equiv |S_A - S_B|$. Antiferromagnetism is treated as the special case of $\mathscr{I} = 0$. The structure of the lowest eigenfunctions is also discussed, in an external magnetic field. (auth)

**32203** EXACT STATISTICAL MECHANICS OF A ONE-DIMENSIONAL SYSTEM WITH COULOMB FORCES. II. THE METHOD OF FUNCTIONAL INTEGRATION. S. F. Edwards (Manchester Univ., Eng.) and A. Lenard. J. Math. Phys., 3: 778-92(July-Aug. 1962). (MATT-108)

The statistical mechanics of a one-dimensional system of charged sheets is studied in the formalism of the grand canonical ensemble. It is shown that the grand partition function may be expressed as a Wiener integral, i.e., as an average of a certain functional of Brownian motion paths. This functional integral is then expressed in terms of the fundamental solution of a partial differential equation of diffusion type. The generality of this method is discussed. When all charges are integral multiples of a common unit the problem is reduced to the determination of the largest characteristic value of an ordinary differential operator with periodic coefficients. An invariance property of the thermodynamic potential is shown to imply charge neutrality in the infinite system limit. A theorem is proven which, in certain cases, excludes the possibility of a thermodynamic phase transition. The method is generalized to yield exact expressions for the n-particle reduced density functions. Some properties of the two-particle functions are discussed. (auth)

**32204** ASYMPTOTIC THEORY OF HAMILTONIAN AND OTHER SYSTEMS WITH ALL SOLUTIONS NEARLY PERIODIC. Martin Kruskal (Princeton Univ., N. J.). J. Math. Phys., 3: 806-28(July-Aug. 1962). (MATT-86)

Consider a system of N ordinary first-order differential equations in N dependent variables, and let the independent variable s not appear explicitly. Let the system depend on a small parameter $\epsilon$ and possess a formal infinite power series expansion in $\epsilon$, and suppose that the limiting system for $\epsilon = 0$ exists and has only periodic solutions. Then a formal solution can be constructed involving infinite power series in $\epsilon$ and satisfying the equations over large domains of s (of order $1/\epsilon$). The true solutions of the system exist over such domains and are asymptotically represented as $\epsilon \to 0$ by the formal solutions. The construction is based on the standard type of formal series solution of a "reduced" system of $N - 1$ equations in $N - 1$ dependent variables and with the new independent variable $\sigma = \epsilon s$; the omitted vari-

able is essentially an angle variable $\phi$ describing the phase around the simple, closed curves. If the original system is Hamiltonian, then the action integral $J = \int p \cdot dq$ can be defined to all orders; the integral is taken around the phase ring. It is proved that J is an integral of the system and that the Poisson bracket of $\phi$ with J is unity, both to all orders. The usefulness of this particular integral is that it is computable locally. The reduced system, after elimination of another dependent variable by means of the constancy of J, can itself be put in Hamiltonian form; if its solutions are nearly periodic, the whole procedure can be reapplied. The theory encompasses proofs of adiabatic invariance to all orders for particular systems such as the harmonic oscillator, the nonlinear oscillator, the charged particle gyrating tightly in a given electromagnetic field, and the longitudinal back-and-forth motion of such a particle trapped between two "magnetic mirrors" in a weak electric field. (auth)

**32205** ON THE RESONANCE ACCELERATION OF A CHARGED PARTICLE IN A MODULATED MAGNETIC FIELD. Iwao Ogawa (Rikkyo Univ., Tokyo). Japan. J. Appl. Phys., 1: 84-91(Aug. 1962). (In English)

Resonance acceleration of a charged particle in a high-frequency modulated uniform magnetic field is investigated analytically. An approximate expression for the motion of the particle under acceleration is obtained by transforming the equation of motion into a Mathieu-Hill type differential equation and by performing a perturbation calculation for a parametric resonance of an arbitrary order. In the case when the acceleration is limited by collision of the particle with the wall of the vessel as well as with a gas molecule, the maximum attainable velocity of the particle is realized when the order of the resonance takes a certain optimum value. The result is fairly consistent with the experiments on electron cyclotron resonance in a radiofrequency ion source. (auth)

**32206** THEORY OF IRREVERSIBLE PROCESSES. I. PARAMETERS OF SMALLNESS. Joseph Higgins. Kgl. Danske Videnskab. Selskab, Mat.-fys. Skrifter, 2: No. 1, 1-50(1962). (In English)

The theory of irreversible processes is reviewed, and the master equation is derived directly in the phase space without reference to the Fourier space. The assumptions involved are closely examined with particular emphasis on the justification of the master equation as derived from the Liouville equation. It is demonstrated that the conditions of a parameter of smallness $\lambda$ associated with the interaction potential energy and large time $t$ compared to a collision time are neither necessary nor sufficient to justify the derivation of the master equation. A necessary, but physically restrictive condition is obtained, and the usefulness of the master equation is discussed. (auth)

**32207** GEOMAGNETICALLY TRAPPED RADIATION PRODUCED BY A HIGH-ALTITUDE NUCLEAR EXPLOSION ON JULY 9, 1962. B. J. O'Brien, C. D. Laughlin, and J. A. Van Allen (Iowa State Univ., Iowa City). Nature, 195: 939-43(Sept. 8, 1962).

A preliminary report is presented of the investigations made with the satellite Injun I (launched July 29, 1961) on the artificial radiation belt produced by a nuclear device exploded at a high altitude near Johnston Island. The satellite had three particle detectors, two of which were directional and the other was omni-directional. The dynamics of geomagnetically trapped particles are described briefly. Plots of the data are given. It is estimated that there were $\sim 10^{24}$ freshly injected and trapped electrons of energy >1.5 Mev in the geomagnetic field one hour after the explosion. The rate of loss of electrons of energy >6 Mev is considered briefly. The measured intensities are compared with those of the Argus belts. (D.L.C.)

**32208** EFFECT OF ADSORBENT TEMPERATURE ON THE BRUNAUER-EMMET-TELLER SURFACE AREA DETERMINED BY KRYPTON ADSORPTION AT 77°K. J. B. Ainscough (United Kingdom Atomic Energy Authority, Springfields, Lancs, Eng.). Nature, 195: 1089-90(Sept. 15, 1962).

A source of error in the use of krypton adsorption at low temperatures to determine Brunauer-Emmett-Teller (BET) surface areas is pointed out. The adsorbent may be at a higher temperature than the surrounding refrigerant, and if the vapor pressure of krypton is not corrected, the BET plots will be curved in the monolayer region. To show the effects of such temperature variations, the surface areas of $UO_3$ and $UO_2$ powders were recalculated using 3.000, 3.500, and 4.000 mm Hg as the vapor pressure of liquid Kr at the adsorbent temperature. (D.L.C.)

**32209** STIMULATED ELECTRON SPIN-FLIP TRANSITION AS THE SOURCE OF 18-MEGACYCLE RADIATION ON JUPITER. L. Landovitz (Yeshiva Univ., N. Y.) and Leona Marshall. Nature, 195: 1186-7(Sept. 22, 1962).

The characteristics of the Jovian radio emission are described. The emission is in the form of intermittent bursts in the frequency range 10 to 35 Mc, with a maximum at 18 Mc, and it appears to come from a localized source with directional properties on Jupiter. The evidence indicates that the Jovian broadcasts are initiated by solar particles. It is suggested that the emission is a decameter emission from electrons making spin-flip transitions in the perturbed magnetic field of Jupiter. Impinging clouds of solar particles could trigger the oscillating magnetic perturbations which would then cause the electrons to make the transitions. The Jovian magnetic field is calculated to be 6.4 gauss at the altitude where the emission occurs. From the observed power of the emission, the rate of electron spin-flips is calculated to be $\sim 10^5$/sec. The cause of the emission variation with the phase of the Jovian day is discussed. (D.L.C.)

**32210** ACTIVATION MECHANISM OF CdS SINGLE CRYSTALS BY LOCAL X-IRRADIATION. A. E. Kiv. Nekotorye Voprosy Priklad. Fiz., 86-93(1961).

The activation of CdS single crystals irradiated by gamma quanta of an energy of less than 0.1 $m_0c^2$ was studied. Activation in the case of local x irradiation was ascribed to the diffusion of lattice defects into the nonirradiated regions and to the displacement of excited electrons and holes. In an ion crystal, the anions may be imparted a positive charge owing to multiple ionization. The recombination time of the photoelectrons was greater than the period of lattice vibrations. The positive anions may therefore be displaced into lattice interstices before they recombine. The concentration of the displaced atoms was estimated to some $10^{15}$ $cm^{-3}$. The sensitivity maximum of a crystal corresponded to the equilibrium distribution of the recombination centers. Distribution was reached in about 15–20 hours. Time depends on the annealing of the defects. A mechanism involving two kinds of recombination centers causes the rise in sensitivity of the crystal during irradiation. The first kind has great trapping cross sections for both electrons and holes, the second has a small electron trapping cross section after the trapping of a hole, and a great hole trapping cross section. The first kind existed also without radiation, the second kind was due to irradiation of the crystal and caused the rise in sensitiv-

ity. It is pointed out that thermal treatment desactivates the crystal. (OTS)

**32211** OUTLINE OF A PERTURBATION THEORY OF THE HYDROGEN MOLECULE. E. Corinaldesi (Instituto Nazionale di Fisica Nucleare, Pisa, Italy and Università, Pisa, Italy). Nuovo cimento (10), 25: 1190-3(Sept. 1, 1962). (In English)

A modified formulation of the Schroedinger equation for the $H_2$ molecule is combined into a single equation with the symmetry conditions for the wave functions. The ground-state properties of the molecule, as calculated by this method, are compared with the experimental values. (T.F.H.)

**32212** FORWARD EMISSION OF PHOTOELECTRONS AT HIGH ENERGIES. Kjell Mork and Haakon Olsen (Norges Tekniske Høgskole, Trondheim, Norway). Phys. Norvegica, 1: No. 1, 23-5(1961). (In English)

The high energy photoelectric cross section in the forward direction was calculated exactly. The Coulomb correction to the second Born approximation forward cross section was found to be remarkably close to Pratt's Coulomb correction to the total Sauter cross section. (auth)

**32213** ON COLLECTIVE EXCITATIONS IN SUPERCONDUCTIVITY THEORY. E. R. Velibekov (Mathematic Inst., Moscow). Physica, 28: 711-20(Aug. 1962). (In English)

Collective excitations in a neutral superconductive Fermi system at a non-vanishing temperature are considered. Along with the kinematic branch of collective excitations there is also a temperature branch of the acoustic type. (auth)

**32214** A NOTE ON THE LONGITUDINAL VARIATION OF WALL TEMPERATURE IN A GLOW DISCHARGE TUBE. V. T. Chiplonkar and S. B. Joshi (Inst. of Science, Bombay). Physica, 28: 726-30(Aug. 1962). (In English)

The longitudinal distribution of the temperature on the wall of a discharge tube, for glow discharge in hydrogen (both normal and abnormal) is investigated as a function of the pressure. At high pressures (>4.0 mm Hg) the highest temperature is reached in the region of the positive column; as the pressure is reduced (2.0 to 0.2 mm Hg) the temperature is largest in the region of the negative glow. The observations are interpreted in terms of the discharge mechanism. (auth)

**32215** MEASUREMENTS OF ELECTROMAGNETIC WAVE ABSORPTION IN SUPER-HIGH-FREQUENCY PULSE DISCHARGE. V. N. Ponomarev (Moscow State Univ.). Pribory i Tekh. Ekspt., No. 3, 96-8(May-June 1962). (In Russian)

Measurements were made at 0.03 to 1.0 $\delta\sigma$. (tr-auth)

**32216** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART I. INTRODUCTION. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 1-5 (July 1962). (In English)

The sixteen alkali halides viz., the fluorides, chlorides, bromides and iodides of lithium, sodium, potassium, and rubidium all possess the rock-salt structure but exhibit a remarkable diversity in their physical properties. Especially notable are the values of their elastic constants, the published determinations of which indicate striking differences in the nature and strength of the binding between the metal and the halogen atoms in the various cases. (auth)

**32217** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART II. THE FREE MODES OF ATOMIC VIBRATION. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 6-10(July 1962). (In English)

It is shown that crystals having the rock-salt structure have nine different frequencies of atomic vibration exhibiting the features of normal modes. One of them is an oscillation of the metal and halogen atoms in opposite phases. Four others are coupled oscillations of the atoms appearing in the cubic layers, while the remaining four are oscillations of the atoms in the octahedral layers. The oscillations in these eight modes alternate in phase from layer to layer and are respectively normal or tangential to those layers. (auth)

**32218** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART III. THE INTERATOMIC FORCES. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 11-14(July 1962). (In English)

It is shown that the restoring forces which arise by reason of the relative displacements of the atoms in the alkali halides during a normal vibration may be expressed by five force constants which are designated by $\alpha$, $\beta$, $\gamma$, $\phi$, and $\psi$. The first two are the principal ones and correspond respectively to a stretching of the bonds between adjacent metal and halogen atoms and to a change of the bond angles. $\gamma$ is the operative force constant for relative displacements of metal and halogen atoms separated from each other by a distance $d\sqrt{3}$. $\phi$ and $\psi$ are the force constants for the relative displacements of like atoms situated at a distance $d\sqrt{2}$ from each other, $\phi$ being the constant for the metal atoms and $\psi$ the constant for the halogens. (auth)

**32219** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART IV. THE EQUATIONS OF MOTION. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 15-19(July 1962). (In English)

Explicit formulas are obtained for the frequencies of the nine normal modes of vibration in terms of the five force constants $\alpha$, $\beta$, $\gamma$, $\phi$, and $\psi$. The formulas show that the principal mode in which the metal and halogen atoms oscillate with opposite phases has also the highest frequency of vibration. The formulas also enable the four octahedral modes and the four cubic modes to be arranged among themselves in a descending order of frequency. (auth)

**32220** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART V. THE EVALUATION OF THE FREQUENCIES. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 20-4(July 1962). (In English)

Simplified formulas involving only two force constants $\alpha$ and $\beta$ are given for the frequencies of the nine normal modes. Reasons are given for identifying the two force constants as being respectively the products of the bulk modulus and of the shearing modulus of the crystal by the distance between adjacent metal and halogen atoms. Calculations made on this basis of the nine frequencies of the rock-salt structure exhibit a highly satisfactory agreement with the spectroscopic data. (auth)

**32221** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART VI. THE ATOMIC VIBRATION SPECTRA. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 25-9(July 1962). (In English)

The frequencies of the nine normal modes of atomic vibration were tabulated for all the sixteen alkali halides. The results of the calculation are in striking accord with the results of the spectroscopic studies in the two leading cases of lithium fluoride and sodium chloride, respectively. The manner in which the structure of the vibration spectra varies with the relative weights of the atoms of metal and halogen is described and discussed. (auth)

**32222** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART VII. EVALUATION OF THE SPECIFIC HEATS. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 30-3(July 1962). (In English)

The determination of the normal modes of atomic vibration in the earlier papers also enables one to identify and enumerate the oscillators of which the quantized energies of vibration constitute the thermal energy of the crystal. Besides the oscillators with the nine discrete frequencies, there are others which give rise to a residual spectrum of vibrations with lower frequencies. The distribution of frequencies in that spectrum is determined and its contribution to the thermal energy is evaluated. (auth)

**32223** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART VIII. THEIR INFRA-RED ACTIVITY. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 34-9(July 1962). (In English)

The dispersion, absorption, and reflection of infrared radiation by the alkali halides receive a satisfactory explanation as consequences of the electric field of the incident radiation inducing a periodic displacement of the negative electric charges located between each pair of metal and halogen atoms in the crystal. The dielectric behavior also receives an acceptable interpretation on the same basis. The appearance of infrared absorption at wavelengths corresponding to the overtones of the frequencies of atomic vibration indicates that the oscillating units in the crystal have dimensions comparable with those of the unit cells. (auth)

**32224** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART IX. SPECTRAL SHIFTS IN LIGHT SCATTERING. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 40-4(July 1962). (In English)

The spectral shifts of doubled frequencies observed in the scattering of light by the alkali halides — rock-salt for example — are discussed and explained, and it is shown that they demonstrate the validity of the approach to the theory of their specific heats developed in the previous parts. (auth)

**32225** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART X. THE LITHIUM SALTS. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 45-51(July 1962). (In English)

The great disparity between the atomic weights of the constituent metal and halogen atoms has a notable influence on the character of the vibration spectra as also on the thermal behavior of the lithium halides. The atomic heat rises rather steeply in the lower ranges of temperature and this is followed by a relatively slow increase toward the limiting value at higher temperatures. (auth)

**32226** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART XI. THE SODIUM SALTS. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 52-9(July 1962). (In English)

Computations of the atomic heats of the four sodium halides are presented and compared with the measured values. The spectroscopic data are the basis of the calculations in the case of NaCl and the atomic vibration frequencies determined from the elastic constants in the others. The vibration frequencies for NaF were corrected to take account of the interactions between atoms of the same species which are strong in that crystal. (auth)

**32227** THE SPECIFIC HEATS OF THE ALKALI HALIDES AND THEIR SPECTROSCOPIC BEHAVIOUR. PART XII. THE POTASSIUM AND RUBIDIUM SALTS. C. V. Raman (Raman Research Inst., Bangalore, India). Proc. Indian Acad. Sci., Sec. A, 56: 60-9(July 1962).

The atomic heats of the potassium and rubidium halides are computed on the basis of the table of vibration frequencies given in Part VI and compared with the observed values in the cases for which these are available. The differences noticed are explained as arising from the octahedral modes having been assigned frequencies lower than the actual ones in the calculation. (auth)

**32228** THERMAL CONDUCTIVITY OF FERMI PARTICLE SYSTEMS. Hiashi Nishimura (Kyushu Univ., Fukuoka). Progr. Theoret. Phys. (Kyoto), 27: 967-87 (May 1962). (In English)

An interpolation formula for the coefficient of thermal conductivity, valid for all temperature, is derived for Fermi gases on the basis of the general quantum-statistical expression, in terms of the time-dependent correlation function. The formula for the conductivity gives the temperature dependence of 1/T in the extremely degenerate case, and leads to an expression for the first correction arising from the Fermi statistics in the slightly degenerate case, and to the Enskog-Chapman theory in the classical limit. The behavior of the conductivity in the strongly degenerate case is clarified by making use of the S-wave approximation. It is shown that the minimum of the conductivity occurs at a temperature 0.164 times as large as the degeneracy temperature. The results of the calculations are used to discuss experiments on liquid $He^3$ by employing the Landau theory of the Fermi liquid. If the effective mass and the degeneracy temperature are taken as $m = 2.34m_0$ and $T_c = 2.13°K$, which values are consistent with experiments on the specific heat and the mass density, agreement is obtained below about 0.07°K by assuming $a = 3.43 \times 10^{-8}$ cm for the scattering amplitude describing the collision between quasi-particles. (auth)

**32229** THERMOELECTRICITY AND NUCLEAR THERMOELECTRIC GENERATORS. Maurizio Giuseppe Vallauri (FIAT S.p.A., Sezione Energia Nucleare, Turin). Rend. AEI (Venezia), 4p. (Sept.-Oct. 1959). (In Italian)

The basic principles of thermoelectricity are discussed with particular respect to the Seebeck effect and its application to the direct conversion of thermal energy into electric energy. On the basis of recent Russian and American studies, some consideration on the selection of materials for use in thermoelectric generators and on the possible realization of nuclear thermoelectric generators are given. (tr-auth)

**32230** MIXED ORGANIC CRYSTALS FOR SCINTILLATION COUNTERS. G. S. Belikova and L. M. Belyayev. Rost Kristallov, Akad. Nauk S.S.S.R., Inst. Krist., 3: 316-21(1961).

The mechanism by which mixed organic crystals of im-

proved luminescence are formed was studied. Mixtures of naphthalene with a luminescent compound were used. The compounds were divided into the following groups: anthracene-phenantrene-chrysene; diphenyl-p-terphenyl-quaterphenyl; dibenzyl-stilbene-tolane; 1,4-diphenylbuta-1,3-diene (DPB)-1,6-diphenylhexa-1,3,5-triene (DPH)-1,1,4,4,-tetraphenylbuta-1,3-diene (TPB); anthranilic acid, methyl anthranilate-N-methyl anthranilic acid-N-phenyl anthranilic acid. The intensity of scintillation was measured by the amplitude method with a scintillation spectrometer. Optical contact between specimens and the photocathode was provided by vaseline. The measurements were carried out with a half-elliptical reflection coated with aluminum. Stilbene monocrystals were used as standards and their scintillation intensity was taken as 100%. The spectra of luminescence were taken on a SF-4 spectrophotometer using the Hg line at 313 mμ. DPB, DPH, anthranilic acid, and methyl anthranilate greatly enhanced the intensity of naphthalene scintillation. The intensity was a function of concentration, especially at low levels. The region of spectra was displaced to the right, in comparison with that of pure naphthalene. Thus, the spectra of crystals, containing DPB, anthranilic acid, and DPH show principal peaks at 392, 406, and 430 mμ, respectively, compared with 345 mμ from pure naphthalene. The spectra show two peaks; at high concentrations, however, one of them (attributed to naphthalene) vanishes. The results are interpreted in terms of interaction between the two molecules in the crystals. Such interaction is a function of the similarity in structure and depends on the formation of solid solutions. The projection of naphthalene was compared with that of the added compounds and the comparisons were in agreement with experimental results. Finally, luminescence is shown to be used as a method of estimating the quantity of the luminescent compound having entered the composition of the crystal. (OTS)

**32231** INVESTIGATION OF THE LOSS OF SEVERAL ELECTRONS BY FAST MULTICHARGED IONS. I. S. Dmitriev, V. S. Nikolaev, L. N. Fateeva, and Ya. A. Teplova (Moscow State Univ.). Zhur. Eksptl'. i Teoret. Fiz., 43: 361-9(Aug. 1962). (In Russian)

The cross sections for loss of two or more electrons by multicharged ions of light elements in helium, nitrogen, argon, and krypton are measured for ion velocities between 2.6 and $12 \times 10^8$ cm/sec. It is found that in the collision between the ions and atoms of the medium electron coupling can be neglected and the losses can be regarded as independent. The mean probability for loss of separate electrons is small and is determined by the magnitude of the binding energy of the electron in the ion. Electron losses chiefly occur for impact parameters of the order of size of the electron shells. The data are in accordance with the picture of electron losses resulting from direct interaction between the electrons and atoms of the medium. Simultaneous loss of several electrons leads to significant changes in the equilibrium charge distribution. (auth)

**32232** EXCITATION OF ATOMS BY HEAVY PARTICLES. L. Vainshtein, L. Presnyakov, and I. Sobelman (Lebedev Inst. of Physics, Moscow). Zhur. Eksptl'. i Teoret. Fiz., 43: 518-24(Aug. 1962). (In Russian)

The transition probabilities and effective cross sections for collisions between atoms and heavy particles are calculated in the quasiclassical approximation for arbitrary values of the transition energy, $\Delta E$, and perturbation matrix elements. The calculations are performed without employing the successive approximation method. (auth)

**32233** OPTICAL CHARACTERISTICS OF ELECTRONS WITH A BAND ENERGY SPECTRUM IN A STRONG ELECTRIC FIELD. L. V. Keldysh (Lebedev Inst. of Physics, Moscow). Zhur. Eksptl'. i Teoret. Fiz., 43: 661-6(Aug. 1962). (In Russian)

The complex dielectric constant of an electron gas in a space-periodic field is calculated for the case when an additional strong homogeneous field is applied. It is shown that the conductivity of such a system has a set of maxima, the widths of which depend on the collision frequency. The sign of the conductivity depends on the mutual orientation of the homogeneous field and on the concentration gradient. (auth)

**32234** GREEN'S FUNCTION AND DISTRIBUTION FUNCTION IN STATISTICAL MECHANICS OF CLASSICAL SYSTEMS. N. N. Bogolyubov, Jr. and B. I. Sadovnikov (Moscow State Univ.). Zhur. Eksptl'. i Teoret. Fiz., 43: 677-88(Aug. 1962). (In Russian)

Two-time advanced and retarded Green's functions and the spectral representation for them are introduced in statistical mechanics of classical systems. A method is developed for deriving an equation chain for such Green's functions. As an illustration of the method the simplest disentanglement is considered which in kinetic equation theory corresponds to the Vlasov equation. The approximate equation for the Green's functions is solved in quadratures. (auth)

**32235** FUNDAMENTAL EQUATIONS OF RADIATION GAS DYNAMICS. R. Goulard (Purdue Univ., Lafayette, Ind.). Preprint No. A & ES 62-4. Prepublication Copy. 57p.

Radiation energy transfer is introduced as an average representation of electromagnetic transport processes. Fundamental properties are defined and an analogy drawn with molecular properties. The interaction parameters with homogeneous matter and with interfaces are discussed. Radiation terms are then introduced into the conservation laws and into several classical relations of fluid dynamics. Some simple configurations of interest in astrophysics, blast waves, etc. are indicated. (auth)

**32236** MOLECULAR MOTIONS IN LIQUID METHANE. S. Hautecler (Centre d'Etude de l'Energie Nucléaire, Mol, Belg.) and H. Stiller. IAEA Preprint No. SM-30/10. 18p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The molecular motions of liquid methane are studied using the beryllium detector method. The rotational motions are found to be completely free at 102°K. A symmetrical splitting of the level L = 1 is observed. A comparison of the experimental results with transition probabilities calculated only from degrees of degeneracy gives good agreement for transitions $\Delta L \geq 2$ and for those transitions $\Delta L = 1$ which have $L \geq 2$ as the initial state. These transitions, therefore, appear to be rather independent of L. Furthermore, the experiments indicate that with respect to their translational motions the molecules behave as in a gas. (auth)

**32237** SOLAR ENERGY APPLICATIONS. OTS Selective Bibliography. (Office of Technical Services, Washington, D. C.). Jan. 1962. 8p. SB-418(Suppl.1) $0.10(OTS)

A list of 110 references to domestic and foreign literature on solar energy applications is presented. The references cited were added to the OTS collection of research reports from July 1960 to Jan. 1962. The referenced literature

contains information concerning measurement of thermal diffusivity, Si solar cells, energy converters, solar stills, solar batteries and Soviet solar energy use. (J.R.D.)

**32238** PROGRESS IN LOW TEMPERATURE PHYSICS. VOLUME III. C. J. Gorter, ed. From the Series in Physics. Amsterdam, North-Holland Publishing Company, 1961. 506p. $16.00.

Eleven review papers are included; separate abstracts have been prepared for 10. One paper was previously abstracted in NSA. (T.F.H.)

**32239** VORTEX LINES IN LIQUID HELIUM II. W. F. Vinen (Royal Society Mond Lab., Cambridge, Eng.). p.1-57 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

The theory of vortex lines and sheets in superfluid He II is reviewed, and the roles that these forms of vorticity play in the hydrodynamics of He II are described. Experimental results are presented and interpreted in terms of the theory. (T.F.H.)

**32240** HELIUM IONS IN LIQUID HELIUM II. G. Careri (Università, Padua). p.58-79 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

A review is presented of studies of ionic structures, ionic motions, ionic mobilities, and ionization and recombination processes in liquid He II. Attention is directed both to the artificial introduction of ions into the liquid for diagnostic purposes and to the properties of naturally occurring ions in the liquid. (T.F.H.)

**32241** THE NATURE OF THE λ-TRANSITION IN LIQUID HELIUM. M. J. Buckingham (Univ. of Sydney) and W. M. Fairbank. p.80-112 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

The specific heat characteristics, thermodynamic properties, and other physical properties of liquid $He^4$ are investigated, at and near the λ-point. The analysis of measurements of physical properties in the vicinity of this transition point is discussed. The fundamental nature of the transition is examined. The superconducting transition in metals is also discussed in terms of the λ-transition theory. (T.F.H.)

**32242** $^3$He CRYOSTATS. K. W. Taconis (Kammerlingh Onnes Lab., Leiden). p.153-69 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

Descriptions are given of several cryostats, calorimeters, and refrigerators using $He^3$ baths. (T.F.H.)

**32243** RECENT DEVELOPMENTS IN SUPERCONDUCTIVITY. J. Bardeen and J. R. Schrieffer (Univ. of Illinois, Urbana). p.170-287 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

A historical outline of experimental and theoretical developments in superconductivity is given. A survey is given of the physical basis and content of several theoretical advances, and of some experimental results that confirm theoretical predictions. (T.F.H.)

**32244** ELECTRON RESONANCES IN METALS. M. Ya. Azbel' and I. M. Lifshitz (Inst. of Technical Physics, Ukrainian Academy of Sciences, Kharkov). Translated from the Russian by W. P. A. Hass. p.288-332 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

Cyclotron and paramagnetic resonances of electrons in metals are investigated. Attention is also given to the predicted phenomenon of non-skin damping of a high-frequency field at resonance. (T.F.H.)

**32245** ORIENTATION OF ATOMIC NUCLEI AT LOW TEMPERATURES. [PART] II. W. J. Huiskamp (Kamerlingh Onnes Laboratorium, Leiden) and H. A. Tolhoek. p.333-95 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

Experimental and theoretical results regarding alpha, beta, and gamma emission by oriented nuclei are reviewed. Several techniques developed for orienting nuclei are examined, including dynamic orientation methods and orientation methods in ferromagnetic and antiferromagnetic materials. (T.F.H.)

**32246** SOLID STATE MASERS. N. Bloembergen (Harvard Univ., Cambridge, Mass.). p.396-429 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

Principles of solid-state masers are outlined. Paramagnetic resonance and relaxation phenomena in maser materials are summarized. Maser circuits, maser noise, and millimeter and infrared solid-state masers are investigated. (T.F.H.)

**32247** THE EQUATION OF STATE AND THE TRANSPORT PROPERTIES OF THE HYDROGENIC MOLECULES. J. J. M. Beenakker (Kamerlingh Onnes Lab., Leiden). p.430-53 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

The properties of the gaseous hydrogenic molecules $H_2$, HD, and $D_2$ at low density and temperature are studied. The low-density restriction narrows the study of the transport properties to the region in which these properties are density-independent. Only linear deviations from the ideal-gas law are permitted in the study of the equation of state, so that only the second virial coefficient need be studied. (T.F.H.)

**32248** SOME SOLID–GAS EQUILIBRIA AT LOW TEMPERATURES. Z. Dokoupil (Kamerlingh Onnes Lab., Lieden). p.454-80 of "Progress in Low Temperature Physics. Vol. III." Amsterdam, North-Holland Publishing Company, 1961.

Qualitative properties of typical solid–gas equilibrium curves of binary systems are discussed. A survey is given of experimental methods for the determination of these equilibrium curves, and of analytical procedures for the determination of small concentrations. Experimental results on binary systems of $H_2$ with $N_2$, CO, $CH_4$, and $O_2$, and on $N_2$–He, are compared with theoretical predictions. (T.F.H.)

## Astrophysics and Cosmology

**32249** (AFCRL-62-225) MAGNETIC FIELDS IN INTERPLANETARY SPACE. Final Engineering Report, January 5, 1961 to December 31, 1961. (Electro-Mechanics Co., Austin, Tex.). Contract AF 19(604)-5221. 73p. (AD-272831)

Available theories of the interplanetary magnetic field are in conflict and measurements which were made by probes and satellites are also in conflict. A critical analysis of the literature suggests a field model which is described. The field at the surface of the earth is about 50,000 gamma; the earth field decreases with distance from the earth according to the inverse cube; the ring cur-

rent, located at about 10 earth radii, opposes the earth field and causes a minimum field intensity of about 0 gamma to appear around 7 earth radii and a maximum field intensity of about 70 gamma to appear at a distance of approximately 13 earth radii; the earth field continues to decrease until a steady limiting value of perhaps 20 gamma is encountered; this steady value continues through most of space; shock waves, both fast and slow, may be encountered and may be expected to have amplitudes of not much greater than 100 gamma and rise times of not much less than 1 ms; and anomalous increases and decreases in magnetic intensity may be expected at times of high solar activity and should, at distances beyond the ring current, be no greater than 50 gamma. (auth)

**32250** (RAD-SR-62-19) IMMEDIATE SOLAR FLARE EFFECTS. Semi-annual Technical Report, March 26–September 26, 1961. Daniel W. Swift (Avco Corp. Research and Advanced Development Div., Wilmington, Mass.). Feb. 15, 1962. Contract AF19(604)-8058. 25p. (AD-271949; AFCRL-1068)

The effective electron collision frequencies in the D-region of the ionosphere are revised. It was found that because of two compensating errors the old and new values of electron collision frequency agree reasonably well. The electron density as a function of time and altitude was computed for a model SID (Spontaneous Ionospheric Disturbance). The model x-ray spectrum responsible for the SID was derived from rocket measurements made during a solar flare. Two models for the electron recombination rate were used, one was derived from laboratory measurement and the other was an empirical model independently determined. SCNA (Sudden Cosmic Noise Absorption) and SPA (Sudden Phase Anomaly) effects were computed from the resulting electron densities. The recombination rate determined from laboratory measurements did not give satisfactory results. (auth)

**32251** ON THE MECHANISM OF STELLAR EXPLOSION. Yôrô Ôno (Hokkaido Univ., Sapporo), Shirô Sakashita, and Noboru Ohyama. Prog. Theoret. Phys. (Kyoto), Suppl., No. 20, 85-112(1961). (In English)

In order to deal with dynamical phenomena of stars, gasdynamical equations and shock relations are examined in relation to the stellar interior. The propagation of shock waves is discussed. As an application, supernova explosion is treated in detail. The origin of planetary nebulae is also considered briefly. (auth)

## Cosmic Radiation

*Refer also to abstracts 31405 and 31927.*

**32252** (NASA-TN-D-1360) THE ELECTROMAGNETIC-RADIATION ENVIRONMENT OF A SATELLITE. PART I. RANGE OF THERMAL TO X-RADIATION. S. Katzoff (National Aeronautics and Space Administration. Langley Research Center, Langley Field, Va.). Sept. 1962. 72p.

The present literature on the short-wavelength (thermal to x-ray) electromagnetic radiation that may strike a satellite of the Earth, the Moon, Mars, or Venus is reviewed. Most of the emphasis is on solar radiation, planetary reflected radiation, and thermal radiation, with some detailed discussion of the spectral composition and variability of the reflected and thermal radiation from the Earth. The lesser sky radiations such as airglow, zodiacal light, and starlight are also briefly discussed. (auth)

**32253** (NASA-TN-D-1361) THE ELECTROMAGNETIC-RADIATION ENVIRONMENT OF A SATELLITE. PART II. RADIO WAVES. Jerry L. Modisette (National Aeronautics and Space Administration. Langley Research Center, Langley Field, Va.). Sept. 1962. 56p.

A compilation of the available information on electromagnetic radiation at radio wavelengths incident on the earth is presented. Radio waves from the sun, moon, and planets and the background radiation from the sky are discussed. A table of the intensities and celestial coordinates of the 2,000 most intense discrete sources (radio stars) is given, together with maps of the brightness temperature of the sky at frequencies of 64 to 910 megacycles per second. (auth)

**32254** (NYO-10243) ISOTOPIC ANALYSIS OF PRIMARY COSMIC RADIATION. M. V. K. Appa Rao (Rochester, N. Y. Univ.). Aug. 15, 1962. Contract AT(30-1)-875. 13p.

It is proposed that the characteristics of nuclear interactions of primary cosmic ray nuclei (in-out interaction) be used to obtain the isotope abundance ratios for different charges. The application of the procedure to singly and doubly charged nuclei is discussed. (auth)

**32255** THE EFFECTS OF COSMIC RAYS ON THE TERRESTRIAL ISOTOPE DISTRIBUTION. Serge A. Korff (New York Univ.). Ann. N. Y. Acad. Sci., 67: 35-54 (Sept. 4, 1956).

The effects of the cosmic rays on the isotope distribution in the surface, atmosphere, and oceans of the earth are considered quantitatively. It is shown that cosmic rays build up both stable and radioactive isotopes, and the amounts to be expected are discussed. The amounts accumulated during the lifetime of the earth are calculated. The deuterium of the oceans, the tritium, and the helium-3 situation are considered. Dating with stable isotopes is discussed. The formation of spallation products in the atmosphere is considered briefly. (D.L.C.)

**32256** DAILY VARIATION OF THE NUCLEON COMPONENT OF COSMIC RADIATION AT JUNGFRAUJOCH. H. Debrunner and F. G. Houtermans (Universität, Bern). Helv. Phys. Acta, 35: 137-46(1962). (In German)

Nucleon intensity measurements are reported for altitudes of 3450 and 3550 m above sea level. The geomagnetic latitude and geographic longitude of the station are 47°56′ N and 7°59′ E respectively, from which data the magnetic cutoff rigidity can be determined as 3.5 Bv. The station has mean counting rates of $3.2 \times 10^6$ counts/hr and $7.7 \times 10^7$ counts/day with relative statistical errors of 0.23 and 0.05% respectively. (tr-auth)

**32257** CYCLOTRON THEORY OF VERY-LOW-FREQUENCY DISCRETE EMISSIONS. R. L. Dowden (Univ. of Tasmania, Hobart). Nature, 195: 1085-6(Sept. 15, 1962).

Information about receding electrons may be obtained from the observed frequency-time shape of discrete very-low-frequency emissions with the cyclotron theory. As an example, the electron energy, helical pitch angle, geomagnetic latitude, and scale frequency were derived from a frequency-time shape "hook." A special type of discrete emissions in which an electron bunch bounces between magnetic mirror points is used to test the cyclotron theory. The agreement is good. (D.L.C.)

**32258** THE ORIGIN OF COSMIC RAYS. Geoffrey Burbidge (Univ. of Chicago). Progr. Theoret. Phys. (Kyoto), 27: 999-1012(May 1962). (In English)

A discussion of the origin of cosmic rays is given. Arguments are given to show that the strong extragalactic radio sources are short-lived, with time scales $\lesssim 10^8$ years. If

the concept of the local supercluster of galaxies is accepted, it is shown that the frequency of strong radio sources is sufficient to produce an energy density of cosmic rays in this supercluster of the order of $10^{-13}$ to $10^{-12}$ erg/cm$^3$. Thus it is possible that the extragalactic component of cosmic rays arising in the supercluster (i.e., within ~30 Mpc of our Galaxy) is appreciable, and this component might account for the majority of the cosmic rays in the Galaxy. Some consequences of this hypothesis are examined. (auth)

**32259** ORIGIN OF COSMIC RAYS. V. L. Ginzburg and S. I. Syrovatsky (Academy of Sciences, Moscow). Prog. Theoret. Phys. (Kyoto), Suppl., No. 20, 1-83(1961). (In English)

Astrophysical (in particular, radioastronomical) data are utilized, in conjunction with observations on the cosmic rays near the earth, in a study of the origin of cosmic radiation. The chemical and spectral composition of the cosmic radiation near earth is described. The lifetimes, motions, acceleration, and other properties of galactic and metagalactic cosmic radiation are studied. A bibliography containing 215 references is included. (T.F.H.)

## Criticality Studies

**32260** (ANL-6582) TWO SPHERICAL FAST CRITICAL EXPERIMENTS (ZPR-III ASSEMBLIES 38 AND 39). J. C. Bates, W. G. Davey, P. I. Amundson, J. M. Gasidlo, J. K. Long, and W. P. Keeney (Argonne National Lab., Idaho Falls, Idaho). July 1962. Contract W-31-109-eng-38. 35p.

Two spherical versions of earlier cylindrical assemblies were used for a critical study of shape effects for fast reactor cores with volumes of 300 to 400 liters. Assemblies 24 (cylindrical) and 38 (spherical) had a high-density metallic U blanket, whereas the set of assemblies numbered 31 (cylindrical) and 39 (spherical) had a low-density U-fueled core (with steel and Al diluents) with a high-density blanket of depleted U. The main features of these assemblies are summarized. Reactivity coefficients of a small number of fissile and nonfissile materials were measured in both assemblies (38 and 39). In Assembly 38 the effects of environment, etc., upon fission rates measured with absolute fission chambers were investigated. Radial fission rate traverses in different directions were made in Assembly 39 to reveal any flux asymmetry due to heterogeneity of the core; no such effect was detected. (auth)

**32261** (LAMS-2744) REFLECTOR SAVINGS OF MODERATING MATERIALS ON LARGE DIAMETER U(93.2%) SLABS. G. E. Hansen, D. P. Wood, and B. Peña (Los Alamos Scientific Lab., N. Mex.). June 1962. Contract W-7405-eng-36. 27p.

Critical mass measurements of 15.0 and 21.0-inch diameter U(93.2%) cylinders unreflected and reflected on one and/or two faces by graphite and the hydrogenous materials water, polyethylene, paraffin, and lucite are reported. (auth)

## Elementary Particles and Radiations

*Refer also to abstracts 31883, 31901, 31920, 31926, 31944, and 31946.*

**32262** (59-RL-2312E) PROTON COMPTON SCATTERING CROSS SECTION FROM 70-Mev THROUGH MESON THRESHOLD. W. B. Jones, H. R. Kratz, and J. Rouvina (General Electric Co. Research Lab., Schenectady, N. Y.). Oct. 1959. 44p.

The differential photon-proton scattering cross section was measured at 70 to 160 Mev at 70, 90, and 135°. An electron synchrotron was used as the x-ray source. Liquid $H_2$ was used as the scattering material, the cryostat for which is described. A total absorption Cherenkov counter served as the energy sensitive detector of the scattered photons. The results indicate that the scattering cross section has a minimum near the threshold for meson photoproduction and an unexpectedly large value at low energies. The differential photon-Be scattering cross section was also measured at 90° at 60 to 130 Mev. (auth)

**32263** (59-RL-2326E) THRESHOLD PRODUCTION OF $\pi^+$ MESONS IN LIQUID HYDROGEN. D. H. Miller and D. A. Hill (General Electric Co. Research Lab., Schenectady, N. Y.). Dec. 1959. 13p.

The angular distribution of $\pi^+$ mesons in the photoproduction reaction $\gamma + p \rightarrow \pi^+ + n$ was measured with a liquid hydrogen bubble chamber for incident photons in a small energy interval around 165 Mev. The distribution is consistent with pure s-wave production. However, there exists a small front-back asymmetry opposite to that expected from extrapolation of higher energy results. (auth)

**32264** (AD-272316) QUANTUM FIELD THEORY AND THE MANY-BODY PROBLEM. T. D. Schultz (Space Technology Labs., Inc. Physical Research Lab., Los Angeles). Oct. 1, 1960. 168p. (STL/TR-60-0000-GR-332)

Notes based on two series of lectures on quantum field theory and the many body problem are presented. An introduction is provided to the recent developments in the theory of the many-body problem which depend heavily on the formalism of quantum field theory. The second quantization, Heisenberg and Schrödinger pictures, many-fermion systems at absolute zero, the electron-phonon system at absolute zero, and many-fermion systems at finite temperatures are discussed. (M.C.G.)

**32265** (AERE-R-4077) INTERMEDIATE MESONS IN NUCLEON-NUCLEON SCATTERING. J. K. Perring and R. J. N. Phillips (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). June 1962. 10p.

To assist the study of pion resonances and their effects, the Born amplitudes for the exchange of one scalar or vector meson are given and a partial wave decomposition is made. (auth)

**32266** (AFCRL-1016) EXCITATION OF HELIUM TO THE $(1s,2p)^1P$ AND $(1s,3p)^1P$ STATES BY PROTON AND ALPHA PARTICLE IMPACT. R. J. Bell (Queen's Univ., Belfast). [1961]. Contract [AF62(052)-131]. 24p. (AD-271747)

The distortion approximation is applied to some excitation processes of He cross-sections being obtained for incident proton energies at 10 to 1000 kev and for incident alpha particle energies at 40 to 4000 kev. For proton impact the maxima cross-sections are found to be 0.18 and 0.035, at 88 and 124 kev respectively; and for alpha particle impact they are found to be 0.61 and 0.101 at 511 and 935 kev respectively. (auth)

**32267** (AFOSR-1728) RESEARCH ON HIGH ENERGY ANTIPARTICLE INTERACTIONS. J. Allan, P. J. Carlson, O. Danielsson, A. G. Ekspong, A. Frisk, B. E. Ronne, and P. Saellstroem (Stockholm. Univ. Inst. of Physics). Sept. 1, 1961. Contract AF 61(052)-452. 55p. (AD-272320)

One of the main lines of the research presented concerns the interaction of antiprotons of 2 Bev/c momentum with the nuclei of nuclear emulsions. The final analysis has to be

preceded by an extensive analysis of interactions caused by negative pions of the same momentum. These results together with the angular and the energy distribution of the secondary pions and the energy distributions of knock-on protons agree well with a cascade calculation based on a knowledge of elementary processes, mainly pion scattering, production, and absorption. The new experimental results thus remove the necessity to consider as severe the bad agreement between an earlier experiment and the cascade calculations. Further, the observation of mesons (K) produced by pions indicate a low cross section for meson (K) production. (auth)

**32268** (BNL-6211) $K^-$-p INTERACTIONS AT 2.24 Bev/c. II: PRODUCTION PROPERTIES. L. Bertanza, V. Brisson, et al. (Brookhaven National Lab., Upton, N. Y.) and M. Goldberg, et al. (Syracuse Univ., N. Y.). [1962]. Contract [AT(30-2)-Gen-16]. 18p.

The various properties of the production modes of $K^-$-p interactions at 2.24 Bev/c are reported. Preliminary estimates of the partial cross sections are included along with information concerning production angular distributions for those combinations of channels which appear well identified, and data on up-down decay distributions from which hyperon polarization information is obtained. (J.R.D.)

**32269** (BNL-6287) RECENT ADVANCES IN THE BUBBLE CHAMBER TECHNIQUE. R. P. Shutt (Brookhaven National Lab., Upton, N. Y.). [1961]. Contract [AT (30-2)-Gen-16]. 110p.

A review of designs and techniques associated with bubble chambers is presented. Data are included on bubble chamber liquids such as $H_2$, $C_3H_8$, $CF_3Br$, and Xe. Other data is included on existing or designed bubble chambers. Illustrative photographs and diagrams are also included. (J.R.D.)

**32270** (DASA-1257) EXACT SOLUTIONS FOR ANISOTROPIC, MULTIPLE SCATTERING BY PARALLEL PLANE DISPERSIONS. Annual Report. Stuart W. Churchill, Chiao-Min Chu, Larry B. Evans, Li-Chiu Tien, and Sing-Chin Pang (Michigan. Univ., Ann Arbor. Coll. of Engineering). Sept. 1961. Contract DA-49-146-XZ-039. 183p. (AD-272325; ORA-03675-1-F)

The effect of anisotropic scattering on radiative transfer was investigated theoretically. Exact solutions were obtained for a plane source obliquely incident on a multiple scattering, parallel plane dispersion by numerical integration. The results are utilized to evaluate the various approximate models which were proposed for radiative transfer and neutron diffusion. A new variable-order, diffusion-type model is proposed as an improved approximation. (auth)

**32271** (DESY-A2.87) GRAPHISCHE DARSTELLUNG DER DIFFERENTIELLEN WIRKUNGSQUERSCHNITTE VON BETHE-HEITLER UND PAULI-WEISSKOPF IN EXTREM RELATIVISTISCHEN GRENZFALL. (Graphic Determination of the Differential Cross Sections of Bethe-Heitler and Pauli-Weisskopf in Extreme Relativistic Limits). J. von Behr (Deutsches Elektronen-Synchrotron, Hamburg). June 1962. 16p.

The differential cross sections for pair productions of fermions with spin $\frac{1}{2}$ was first given by Bethe-Heitler, and the corresponding expression for bosons with spin 0 was given by Pauli-Weisskopf. At high primary $\gamma$ energy, there are significant deviations from these first approximations. In the present report, extremely relativistic approximations of the Bethe-Heitler and Pauli-Weisskopf formulas were derived and represented graphically. These approximations are not valid for angles $\theta \ll 1$. The dependence on the primary energy is represented in a simple manner. The extremely relativistic limiting cases for fermions and bosons are derived. The effect of shielding on the scattering cross section is determined. (J.S.R.)

**32272** (DESY-A2.88) GRAPHISCHE DARSTELLUNG DES DIFFERENTIELLEN WIRKUNGSQUERSCHNITTES VON MUONEN NACH DER BETHE-HEITLER-FORMEL FÜR DESY-ENERGIEN. (Graphic Determination of Differential Cross Sections of Muons According to the Bethe-Heitler Formula for DESY Energies). J. von Behr (Deutsches Elektronen-Synchrotron, Hamburg). June 1962. 5p.

In an earlier work (DESY-7.2.62) a very energy-independent approximation of the Bethe-Heitler formula was constructed. It was, however, not valid for small values of the pulse transmitted. The Bethe-Heitler formula is represented graphically in the present report for two $\gamma$ energies—3 and 6 Bev at angles of 2°. It is noted that $T_F$ contains essentially no modifications in the range considered and for small Z. (J.S.R.)

**32273** (DESY-A2.89) DIE ENERGIE-RICHTUNGS-VERTEILUNG VON PAAR-ELEKTRONEN, DIE DURCH EIN BREMSSTRAHLUNGS-SPEKTRUM ERZEUGT WERDEN UND VIELFACHSTREUUNG ERLEIDEN. (The Energy-Angular Distribution of Electron Pairs Produced by a Bremsstrahlung Spectrum and Multiply Scattered). J. von Behr (Deutsches Elektronen-Synchrotron, Hamburg). June 1962. 14p.

The energy-angular distribution of electron pairs is stated for simple conditions, and an extension to other energies and film thickness is possible. The case of multiple scattering of bremsstrahlung by similar targets, as that in which pair production occurs, was considered. The rule of thumb for the validity range of the necessary formulas for multiple scattering is given. (M.C.G.)

**32274** (NP-12032) RESONANZEN IM KOMPLEXEN DIAGRAMM DER $\pi$N-VORWÄRTSSTREUAMPLITUDE. (Resonances in Complex Diagrams of the $\pi$N-Forward Scattering Amplitude). G. Hoehler and G. Ebel (Karlsruhe, Germany. Technische Hochschule. Institut fur Theoretische Kernphysik). [1962]. 43p.

The $\pi$N-forward scattering amplitudes were calculated from the total cross sections, using the dispersion relations and the optical theorem. In order to facilitate the discussion of the nucleon resonances, the results are given as diagrams, showing the energy dependence of the complex vectors $q\,F_b$ for total isospin $I = \frac{1}{2}, \frac{3}{2}$, and charge exchange scattering ($q$ = pion momentum, $F_b = D_b + i\,A_b$ forward scattering amplitude, both in the c.m. system). In this representation the contribution of an elastic resonant partial wave is a circle of radius $(2J + 1)/4$ which is described in a counter-clockwise direction as the energy increases. In the inelastic case the radius is smaller by an amount which depends on the absorption. Several arguments are given in favor of the opinion that a zero order description of photoproduction of pions is probably as complicated as the description of pion-nucleon scattering. In particular it is not justified to neglect the Born term for the $\pi^0$ production and the M 1 $P_{\frac{1}{2}}$ amplitude of the Born term for the $\pi^+$ production. (auth)

**32275** (NP-12034) POLARISATION DER RÜCKSTOS-SNUKLEONEN BEI DER PHOTO-PION-ERZEUGUNG AM WASSERSTOFF IM GEBIET DER ERSTEN RESONANZ. (Polarization of Back Scattered Nucleons in Photopion Production on Hydrogen in the Region of the First Resonance). Alfred Muellensiefen (Karlsruhe, Germany. Technische Hochschule Institut für Theoretische Kernphysik). [1961]. 18p.

The most important formulas for calculation of polariza-

tion were collected. Then the expected polarization was calculated utilizing earlier amplitude analyses as well as the dispersion theory of Chew et al. Prediction of the polarization by multi-pole amplitudes determined from angular distributions is discussed. Results are discussed. (M.C.G.)

**32276** (NP-12035) PHOTOERZEUGUNG VON K-MESONEN AN NUKLEONEN. (Photoproduction of K Mesons on Nucleons). A. Muellensiefen (Karlsruhe, Germany. Technische Hochschule. Institut für Theoretische Kernphysik). [1961]. 19p.

A short review of theoretical work on the photoproduction of K mesons is given. It was necessary to evaluate the second order perturbation theory and to compare the results with experimental data. An estimation was made of the size of the resonance contribution to results obtained by the perturbation theory. Calculations of the coupling constants and relative parities by Moravcsik and Sakurai are discussed. Tables of data on the photoproduction of K mesons are included. (M.C.G.)

**32277** (NYO-9288) NUCLEON ANTI-NUCLEON ANNIHILATIONS INTO TWO PARTICLE FINAL STATES. Nicholas J. Sopkovich (Carnegie Inst. of Tech., Pittsburgh). June 1962. Contract AT(30-1)-882. 59p.

Modified Born approximation calculations were made for the annihilations $\underline{N}N \rightarrow \underline{K}K$ and $N\underline{N} \rightarrow \underline{\Lambda}\Lambda$. The transitions are assumed dominated by peripheral interactions. The effects of the other available channels are represented by an absorptive potential fit to the NN elastic scattering. From a geometrical optics solution of the potential problem, a form for the modification of the Born approximation partial wave amplitudes is suggested. Comparison of theory with experiment results in agreement for $p\underline{p} \rightarrow K^-K^+$ at 1.61 Bev/c and $p\underline{p} \rightarrow \Lambda^0\Lambda^0$ at 3.30 Bev/c for coupling constants and parities obtained by many other workers; disagreement that occurs for $p\underline{p} \rightarrow \Lambda^0\Lambda^0$ at 1.61 Bev/c is taken to indicate an inadequacy of the geometrical optics approximation. Further experimental consequences are discussed. (auth)

**32278** (NYO-10246) STUDY OF NUCLEAR INTERACTIONS PRODUCED BY 275 Mev DEUTERONS IN NUCLEAR EMULSIONS. M. V. K. Appa Rao and P. J. Lavakare (Rochester, N. Y. Univ.). Aug. 31, 1961. Contract AT(30-1)-875. 16p.

Nuclear interactions produced in nuclear emulsions by deuterons of mean energy 275 Mev were analyzed. The relevant parameters, needed for the study of the primary cosmic ray deuterons were obtained at this energy. (auth)

**32279** (ORNL-3329) STUDIES OF THE LONGITUDINAL DEVELOPMENT OF HIGH-ENERGY ELECTRON-PHOTON CASCADE SHOWERS IN COPPER. C. D. Zerby and H. S. Moran (Oak Ridge National Lab., Tenn.). Oct. 2, 1962. Contract W-7405-eng-26. 85p.

Numerical results of the track lengths of photons and charged particles and the energy deposition as a function of depth out to 10 radiation lengths in Cu are presented for the case of electron-initiated electron-photon cascade showers. The incident energy varied from 50 to 45,000 Mev in these cases. Monte Carlo methods were used to calculate the longitudinal development of the showers in order to obtain the data that are presented. The Bethe-Heitler cross sections which include screening and the correct energy dependence were used for bremsstrahlung and pair production events. The Klein-Nishina formula was used for Compton scattering. Energy losses by ionization collisions were treated as a continuous energy degradation process. (auth)

**32280** (ORO-538) AN EXPERIMENTAL INVESTIGATION OF ELECTRON TRAJECTORIES IN AN AXIALLY SYMMETRIC MAGNETIC FIELD. Technical Report No. 3. R. F. Stetson, B. N. A. Lamborn, and D. L. Lafferty (Florida. Univ., Gainesville). Mar. 15, 1962. Contract AT(40-1)-2783. 11p.

The behavior of electron beams of variable energies injected into an axially symmetric magnetic field was investigated. A theoretical study showed and the experiments verified that a beam injected in the $r$-$\theta$ plane of a field with suitably chosen radial gradient can be made to spiral inward from the injection radius and to reflect off some finite inner radius. With the proper choice of beam energy, the path traversed by the beam can be made very large. (auth)

**32281** (ORO-569) PARTICLE TRAJECTORIES IN A STATIC MIRROR FIELD. Technical Report No. 4. D. L. Lafferty and B. N. A. Lamborn (Florida. Univ., Gainesville). June 27, 1962. Contract AT(40-1)-2783. 17p.

The properties of median-plane trajectories of a charged particle injected tangentially into a magnetic mirror field were determined. An effective radial potential was used and the possible motions of the particle were determined from the corresponding radial phase-plane trajectories. It is shown that fields with a variable radial gradient can have phase plots containing saddle-point singularities. The particle trajectories near these singularities are characterized by long radial periods and, consequently, long path lengths. The critical trajectory passing through a saddle point has an infinite radial period; a particle injected along such a trajectory would then spiral inward toward the saddle-point and never return to the injection radius. (auth)

**32282** (TID-16550) AN IMPROVED DETERMINATION OF THE BRANCHING RATIO OF THE DECAY OF THE $K_1^0$ MESON. M. Chretien, et al. (Brandeis Univ., Waltham, Mass.); H. R. Crouch, Jr., et al. (Brown Univ., Providence); J. P. Averell, et al. (Harvard Univ., Cambridge, Mass.); and L. Guerriero, et al. (Massachusetts Inst. of Tech., Cambridge). [July 3, 1962]. Contracts AT(30-1)-2098, AT(30-1)-2752, and AT(30-1)-2262. 3p.

A study was made of the neutral decay mode of the $K_1$-meson whose products are taken to be two neutral pions. The $K_1$-mesons were produced in a bubble chamber by 1140 and 1060 Mev/c $\pi^-$-mesons. In 180,000 pictures, 440 charged decays of the $K_1$-meson into $\pi^+$- and $\pi^-$-mesons and 172 neutral decays into two $\pi^0$-mesons were found. The number of 2, 3, and 4 gamma events was 85, 64, and 23 respectively. On the basis of these events the ratio of the number of $K_1$-mesons decaying into two $\pi^0$-mesons to the total number of $K_1$ decays was found to be $0.296 \pm 0.027$. (M.C.G.)

**32283** (TID-16552) THE THEORY OF INELASTIC PROTON-DEUTERON SCATTERING. Alan H. Cromer (Northeastern Univ., Boston and Harvard Univ., Cambridge, Mass.). [1962]. 44p.

Calculations are made of the small angle inelastic proton-deuteron cross section near threshold. The theory assumes impulse approximation to relate the interaction of the incident proton with the target nucleons to the free nucleon-nucleon scattering amplitude. Effective range theory is used to describe the final state interaction of the target nucleons in the S-state. The cross section at small angles is dominated by events which leave the target nucleons in the singlet S-state. The cross section depends on three nucleon-nucleon parameters: the coefficients of the singlet S- and triplet S-terms in the cross section, $\Sigma_s$ and $\Sigma_t$ and the sum of the proton-neutron and proton-proton differential cross sections, $\sigma_{np} + \sigma_{pp}$. Three

parameters are determined at the laboratory angles of 5°, 10°, 15°, and 20° by making a least squares fit to the experimental measurements of Stairs, Wilson and Copper. This fit mainly determines $\Sigma_2$. This parameter is particularly sensitive to the isotopic spin zero nucleon-nucleon amplitudes and thus these values of $\Sigma_2$ may be of use in future phase shift analyses. (auth)

**32284** (TID-16557) STRANGE PARTICLE RESONANCES FROM $\pi^+$-p INTERACTIONS AT 2 Gev. H. W. Foelsche, E. C. Fowler, H. L. Kraybill, and J. R. Sanford (Yale Univ., New Haven and Brookhaven National Lab., Upton, N. Y.). [1962]. Contracts [AT(30-1)-1349 and AT-30-2-GEN-16]. 8p.

A study was made of the production of K mesons and hyperons in $\pi^+$-p collisions at an incident pion kinetic energy of 1.95 Bev. An electrostatically purified beam of $\pi^+$ mesons was photographed in a 20-in. hydrogen bubble chamber. The 40,000 pictures produced, containing a total beam track length of 880 events/mb, were scanned for charged and neutral decays originating in two-pronged collisions. A preliminary value of 0.25 ± 0.04 mb was obtained for the cross section of the reaction $\pi^+ + p \rightarrow \Sigma^+ + K^+$. The position and width of effective mass peaks indicating $Y_1^*$ and $K^*$ were consistent with values previously reported. (M.C.G.)

**32285** (TID-16558) $\pi^+$-p INTERACTIONS NEAR 1 Bev. H. Foelsche, E. C. Fowler, H. L. Kraybill, J. R. Sanford, and D. Stonehill (Yale Univ., New Haven and Brookhaven National Lab., Upton, N. Y.). [1962]. Contracts [AT(30-1)-1349 and AT-20-2-GEN-16]. 27p.

A study was made of $\pi^+$-$\pi^+$ and $\pi^+$-p interactions produced by a beam of $\pi^+$ mesons incident on a hydrogen bubble chamber. Photographs were taken for $\pi^+$ energies of 910, 1090, and 1260 Mev in order to study interactions at energies in the leading edge of the second maximum in the $\pi^+$-p total cross section. In order to determine the position and width of the $\rho$ resonance the data were fit to a modified form of the Chew-Low prediction. Evidence for the $\zeta$ resonance is lacking. In the study of multi-pion production events numerous effective mass distributions for the proton and various pion combinations were compiled. (M.C.G.)

**32286** (TID-16566) MAGNETIC MOMENT OF THE LAMBDA. W. Kernan, T. Novey, S. Warshaw (Argonne National Lab., Ill.); and A. Wattenberg (Illinois. Univ., Urbana). [1962]. Contract [AT(11-1)-182]. 7p.

An experiment was carried out to measure the magnetic moment of the Λ hyperons. The Λ hyperons were produced from a secondary beam of 1.2-Bev/c $\pi$ mesons. The hyperons were polarized, so the magnetic moment was determined by measuring the precession of the direction of polarization in a strong magnetic field. A total of 88 Λ hyperons was identified in 40,000 pictures. Only about 20 of these passed through the precession magnet. Results indicated a value for the magnetic moment of $0 \pm \frac{1}{2}$ nuclear Bohr magnetron. (M.C.G.)

**32287** (TID-16662) (d,t) REACTIONS ON NUCLEI NEAR N = 28. T. H. Braid and B. Zeidman (Argonne National Lab., Ill.). June 1962. Contract [W-31-109-eng-38]. 5p. (UAC-6522)

The (d,t) reactions on targets of $V^{51}$, $Cr^{52}$, $Fe^{54}$, $Fe^{56}$, $Mn^{55}$, and $Ni^{58}$ were investigated using 21.6-Mev deuterons. Data are included on $Fe^{54}$ and $Fe^{56}$ spectra, and information on the other reactions. (J.R.D.)

**32288** (TID-16666) ALPHA SCATTERING BY THE TITANIUM ISOTOPES. H. W. Broek and J. L. Yntema (Argonne National Lab., Ill.). June 1962. Contract [W-31-109-eng-38]. 5p. (UAC-6533)

The five stable Ti isotopes were studied by scattering of 43-Mev $\alpha$ particles. Information is given concerning angular distributions and excited states. Data are included on energy spectrum of particles scattered from $Ti^{48}$ and angular distributions of groups A, B, and C of this isotope. (J.R.D.)

**32289** (TID-16677) NEUTRAL MESON PRODUCTION IN $\pi^-$-p COLLISIONS IN THE 1 Bev/c REGION. M. Chretien (Brandeis Univ., Waltham, Mass.); F. Bulos, et al. (Brown Univ., Providence); C. A. Bordner, Jr., et al. (Harvard Univ., Cambridge, Mass.); B. Nelson, et al. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science); L. Guerriero, and S. Waldner (Padua. Università. Istituto di Fisica and Italy. Istituto Nazionale di Fisica Nucleare, Padua). [May 15, 1962]. Contract [AT (30-1)-2262]. 9p.

The charge exchange reaction $\pi^- + p \rightarrow \pi^0 + N$ was investigated. In one experimental series a collimated and focused $\pi^-$ beam was directed axially at the target. The films were scanned for $e^+ - e^-$ pairs. The other technique involved passing the $\pi^-$ beam directly through the chamber without an $H_2$ target, at incident momenta, in this case 1060 and 1140 Mev/c. The chamber filling was propane, methyl iodide, and ethane. The films were scanned for events in which two or more electron pairs point to a $\pi^-$ interaction in the chamber with no visible secondaries. Data and comment on results are included. (J.R.D.)

**32290** (UCRL-9686) EVIDENCE FOR A T = 0 RESONANCE IN THE $\Sigma\pi$ SYSTEM. Margaret H. Alston, Luis W. Alvarez, Philippe Eberhard, Myron L. Good, William Graziano, Harold K. Ticho, and Stanley G. Wojcicki (California. Univ., Berkeley. Lawrence Radiation Lab. and California. Univ., Berkeley). Apr. 28, 1961. Contract W-7405-eng-48. 17p.

A study was made of the following reactions: $K^- + p \rightarrow \Sigma^+ + \pi^- + \pi^- + \pi^+$, $K^- + p \rightarrow \Sigma^- + \pi^+ + \pi^+ + \pi^-$, and $K^- + p \rightarrow \Sigma^0 + \pi^0 + \pi^+ + \pi^-$. Nineteen events of the first type and 13 events of the second type were observed, corresponding to cross sections of 0.19 ± 0.06 and 0.12 ± 0.05 mb, respectively. The third type could not be identified unambiguously. It was concluded that the data for Σ and three pions are most naturally interpreted by invoking a T = 0 $\Sigma\pi$ resonance. (M.C.G.)

**32291** (UCRL-10221(Rev.)) ELASTIC $K^+$-p SCATTERING AT 0.97, 1.17, AND 1.97 Bev/c. V. Cook, D. Keefe, L. T. Kerth, P. G. Murphy, W. A. Wenzel, and T. F. Zipf (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 15, 1962. Contract W-7405-eng-48. 13p.

An experiment on elastic $K^+$-p scattering at 970 to 1970 Mev is described. Spark chambers are used to measure $d\sigma/d\Omega$ at angles greater than about 10°, and counters are used for the small-angle scattering. Results showed a deviation of angular distributions from anisotropy that increases with energy. Other observations were that the S-wave contribution to the elastic scattering is decreasing rapidly at 1 Bev/c and that predictions of phase shifts lead to a more or less stable estimate of the real part of the forward scattering amplitude. At 1970 Mev/c the angular distribution shows a pronounced diffraction peak on a small almost isotropic distribution of about 0.05 mb/sr. (J.R.D.)

**32292** (UCRL-10222(Rev.)) ELASTIC $K^-$-p SCATTERING BETWEEN 700 AND 1400 Mev/c. E. F. Beall, W. Holley, D. Keefe, L. T. Kerth, J. J. Thresher, C. L. Wang, and W. A. Wenzel (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 15, 1962. Contract W-7405-eng-48. 13p.

A study of $K^-$-p interactions at about the 1.05 Bev/c resonance was conducted using spark chambers. The results are shown in figures as center-of-mass differential cross sections. The imaginary parts were computed from known total cross sections by the optical theorem, and the real parts from forward dispersion relations. A discussion of results is included. (J.R.D.)

**32293** (UCRL-10230) MUONIC DECAYS OF Σ AND Λ HYPERONS. William E. Humphrey, Janos Kirz, Arthur H. Rosenfeld (California. Univ., Berkeley; California. Univ., Berkeley. Lawrence Radiation Lab.); and Jack Leitner (Syracuse Univ., N. Y.). May 31, 1962. Contract W-7405-eng-48. 11p.

Information was compiled on the branching fraction for the processes $\Sigma^+ \rightarrow \mu^+ + \nu + n$ and $\Lambda \rightarrow \mu^- + \nu + p$. A selected sample of 8000 $\Sigma^-$, 1800 $\Sigma^+$, and 4200 Λ hyperons was examined for muonic decays. No such events were found. Techniques for μ-decay detection are described. (M.C.G.)

**32294** (UCRL-10232) K* PRODUCTION AND DECAY. Margaret H. Alston, George R. Kalbfleisch, Harold K. Ticho, and Stanley G. Wojcicki (California. Univ., Berkeley. Lawrence Radiation Lab.). June 19, 1962. Contract W-7405-eng-48. 15p.

The properties of K* were studied by investigating the reaction $K^- + p \rightarrow \overline{K}^0 + \pi^- + p$ at the incident momentum of 1.22 Bev/c ($E_{cm}$ = 1895 Mev). A separated $K^-$ beam was used to guide approximately 200,000 $K^-$ mesons into the 72-in. $H_2$ bubble chamber. The events were analyzed by computer. Data and discussion are included on cross sections for the events as expressed by the reaction equation, angular distributions, spin resonance, and decay distributions. An analysis of the one-pion exchange process which is assumed to dominate the listed reaction is also included. (J.R.D.)

**32295** (UCRL-10233) STUDY OF RESONANCES IN THE Σ-π SYSTEM. Margaret H. Alston, Luis W. Alvarez, Massimiliano Ferro-Luzzi, Arthur H. Rosenfeld, Harold K. Ticho, and Stanley G. Wojcicki (California. Univ. Berkeley, Lawrence Radiation Lab. and California. Univ., Berkeley). June 12, 1962. Contract W-7405-eng-48. 14p.

In a study of resonances in the Σ-π system, an analysis of reactions in which a Σ hyperon and two or three pions are produced in $K^-$-p interactions at 1.22 ± 0.040 and 1.51 ± 0.050 Bev/c incident momentum was made using the LARL 72-in. $H_2$ bubble chamber. Data on the reaction $K^- + p \rightarrow \Sigma$ + pions are included. (J.R.D.)

**32296** (UCRL-10234) $K^-$-p CHARGE EXCHANGE AT 1.22 Gev/c. Massimiliano Ferro-Luzzi, Frank T. Solmitz, and M. Lynn Stevenson (California. Univ., Berkeley. Lawrence Radiation Lab.). June 6, 1962. Contract W-7405-eng-48. 8p.

The reaction $K^- + p \rightarrow \overline{K}^0 + n$ was studied at 1.22 Bev/c using the LARL 72-in. $H_2$ bubble chamber and a separated $K^-$ beam. The angular distribution for the reaction in the center of mass shows a prominent backward peaking of the $\overline{K}^0$. Preliminary results at 1.53 Bev/c incident momentum indicate a lessening or disappearance of the effect. Data on the reaction and other comments concerning the effect are included. (J.R.D.)

**32297** (UCRL-10237) $\Lambda\pi^+\pi^-\pi^0$ AND Λ + NEUTRAL FINAL STATES IN $K^-$-p INTERACTIONS AT $K^-$ MOMENTA OF 1.22 AND 1.51 Gev/c. Janice Button-Shafer, Massimiliano Ferro-Luzzi, Joseph J. Murray, M. Lynn Stevenson, and Frank T. Solmitz (California. Univ., Berkeley and California. Univ., Berkeley. Lawrence Radiation Lab.). June 5, 1962. Contract W-7405-eng-48. 16p.

The effective and missing mass distributions of the final states in $K^-$-p interactions at $K^-$ momenta of 1.22 and 1.51 Bev/c are discussed and shown graphically. (N.W.R.)

**32298** (UCRL-10244) TEST OF CHARGE SYMMETRY OF $K^+$ AND $K^0$ MESONS IN THE ASSOCIATED PRODUCTION PROCESS. Janice Button-Shafer, et al. (California. Univ., Berkeley. Lawrence Radiation Lab.); Martin Block, et al. (Northwestern Univ., Evanston, Ill.); and Richard Kraemer, et al. (Johns Hopkins Univ., Baltimore). June 5, 1962. Contract W-7405-eng-48. 13p.

A charge-symmetry experiment is described in which the 72-in. bubble chamber was filled with liquid deuterium and a beam of positive pions at 1.23 Bev/c was directed from the Bevatron into it. The reactions studied include $\pi^+ + d \rightarrow \Lambda$ (or $\Sigma^0$) + $K^+$ + p, $\pi^- + d \rightarrow \Lambda$ (or $\Sigma^0$) + $K^0$ + n, $\pi^+ + d \rightarrow p + \Lambda + K^+$, $\pi^- + d \rightarrow n + \Lambda + K^0$, $\pi^+ + d \rightarrow p + \Sigma^0 + K^+$, and $\pi^- + d \rightarrow n + \Sigma^0 + K^0$. Comparison of data on differential cross section and symmetry of lambda decay for the first two reactions listed shows that the reactions, and hence K mesons, are charge symmetric. (J.R.D.)

**32299** (UCRL-10249) CYLINDRICAL SPARK-CHAMBER ARRAY USED FOR THE MEASUREMENT OF ANGLE, RANGE, AND POLARIZATION IN A STUDY OF $K^-$-p INTERACTIONS. E. F. Beall, W. Holley, D. Keefe, L. T. Kerth, J. J. Thresher, C. L. Wang, and W. A. Wenzel (California. Univ., Berkeley. Lawrence Radiation Lab.). May 25, 1962. Contract W-7405-eng-48. 9p.

A spark-chamber study on $K^-$ interactions with protons at 700 to 1400 Mev/c is described. A Bevatron unseparated negative beam ($\pi^-$ and $K^-$) was used. Large solid angle and high angular resolution were obtained by surrounding a liquid $H_2$ target by a ten-gap cylindrical chamber. Techniques used to measure polarization of reaction products are described along with methods of defining the incident momentum for each event and procedures for establishment of various parameters. (J.R.D.)

**32300** (UCRL-10259) UNSTABLE PARTICLES IN S-MATRIX THEORY. Henry P. Stapp (California. Univ., Berkeley. Lawrence Radiation Lab.). May 23, 1962. Contract W-7405-eng-48. 8p.

Apparent ambiguities of definitions of masses and lifetimes of unstable particles that depend either on the introduction of unperturbed Hamiltonians and their eigenstates, or on an assumed correspondence between resonances and elementary fields, are noted. The S-matrix definition is unambiguous; the positions of poles in the first unphysical sheets are given by the zeros of the Fredholm denominator function, which is a function only of an appropriate center-of-mass energy. The mass and lifetime of a particle are consequently independent of the variables of the scattering process or of the particular process to which the particle contributes. The invariance of the Fredholm denominator under charge conjugation, which is a consequence of CPT invariance, ensures the equality of masses and lifetimes of relatively conjugate antiparticles. Unstable particles are closely akin to stable ones; by the factorization of the residues of unstable-particle poles, unstable-particle scattering functions quite analogous to ordinary scattering functions can be unambiguously defined. Like ordinary scattering functions they are defined only on the mass shell, the fixed masses of the unstable particles being well-defined complex numbers. The needed factorizability of the residue is an immediate consequence of Fredholm's second theorem. The rigorous existence of the Fredholm functions required for con-

tinuation, by means of unitarity, through the multiparticle physical cuts onto the first unphysical sheets is not yet established in the generality needed for the widest applicability of the results. (auth)

**32301** (UCRL-10277) EXPERIMENTAL STUDY OF THE THREE-BODY LEPTONIC DECAY MODES OF THE $K^+$ MESON. John L. Brown, John A. Kadyk, George H. Trilling, Remy T. Van de Walle (California. Univ., Berkeley. Lawrence Radiation Lab.; California. Univ., Berkeley); Byron P. Roe and Daniel Sinclair (Michigan. Univ., Ann Arbor). June 5, 1962. Contract W-7405-eng-48. 12p.

A study was made of the three-body leptonic decay modes ($K^+_{l3}$) of the $K^+$ mesons ($K^+_{e3} \rightarrow e^+ + \pi^0 + \nu$ and $K^+_{\mu 3} \rightarrow \mu^+ + \pi^0 + \nu$). The vector, scalar, and tensor couplings were studied. It was concluded that only vector coupling agrees with the $K^+_{e3}$ and $K^+_{\mu 3}$ data. The actual identity of the coupling was tested by comparing $f^{\mu}_{v}$ and $f^{e}_{v}$. The result was in good agreement with expectations. (M.C.G.)

**32302** (UCRL-10286) STUDY OF STRANGE-PARTICLE RESONANT STATES PRODUCED IN 1.89-2.24 Gev/c $\pi^-$ + p INTERACTIONS. Gideon Alexander, Laurence Jacobs, George R. Kalbfleisch, Donald H. Miller, Gerald A. Smith, and Joseph Schwartz (California. Univ., Berkeley and California. Univ., Berkeley. Lawrence Radiation Lab.). June 11, 1962. Contract W-7405-eng-48. 12p.

Preliminary results obtained in a study concerning the higher-momentum portion of a film of events in the LRL 72-in. bubble chamber which was exposed to a $\pi^-$ beam at 1.55 to 2.35 Bev/c are discussed. Most distributions at 1.89 and 2.00 Bev/c are qualitatively similar and distinct from those at 2.16 and 2.24 Bev. Three resonances, $Y^*_1$ (1385 Mev), $Y^*_0$ (1405 Mev), and $Y^*_0$ (1525 Mev), are produced strongly at 1.89 and 2.04 Bev/c. The data for the $Y\pi$ system at the two higher-momenta show enhancement in the region $MY\pi$ = 1685 Mev. This enhancement is attributed to the $I = 1$ $Y\pi$ system. Two $K\pi$ resonant states, $K^*$ (885 Mev) and $K^*$ (730 Mev), are observed. (J.R.D.)

**32303** (UCRL-10310) INTERACTIONS OF $K^-$ MESONS IN HYDROGEN IN THE 300- TO 850-Mev/c REGION. Pierre L. Bastien, J. Peter Berge, Orin I. Dahl, Massimiliano Ferro-Luzzi, Janos Kirz, Donald H. Miller, Joseph J. Murray, Arthur H. Rosenfeld, Robert D. Tripp, and Mason B. Watson (California. Univ., Berkeley. Lawrence Radiation Lab. and Californja. Univ., Berkeley). June 19, 1962. Contract W-7405-eng-48. 11p.

Results are presented on the total and partial cross sections for $K^-$ mesons incident on protons at laboratory momenta of 293, 350, 390, 434, 513, 620, 762, and 850 Mev/c. For each momentum setting, a total of several thousand interactions were recorded and analyzed. (J.R.D.)

**32304** (UCRL-10335) PROGRAM FAKE: MONTE CARLO SIMULATION OF BUBBLE CHAMBER EVENTS. Gerald R. Lynch (California. Univ., Berkeley. Lawrence Radiation Lab.). July 10, 1962. Contract W-7405-eng-48. 52p.

Program FAKE is a Fortran Monte Carlo program that generates events in a bubble chamber according to prescription and simulates the output of the PANG track-reconstruction program. Descriptions are given of the method used to generate events that are distributed in accordance with a phase-space distribution, and the method used to modify the measurable quantities to simulate the effects of measurement errors and multiple Coulomb scattering. (auth)

**32305** REMARKS ON THE ISOBARIC MODEL FOR MULTIPLE PARTICLE PRODUCTION. P. Berger (Université, Louvain, Belgium). Ann. soc. sci. Bruxelles, Ser. I, 76: 13-18(1962). (In French)

In the isobaric model for multiple pion production, it is assumed that the isobars need a long lifetime compared to the interaction time. The interaction time for various reactions is estimated from a semiclassical picture of the collisions, and compared with the lifetime of the isobars, which can be estimated from the resonance widths in the total $\pi - N$ cross section. Only at very high velocities of the outgoing particles is the long-isobar-lifetime hypothesis true. A table is computed of "isobaric thresholds," i.e., the energy of the incoming pions or nucleons needed to insure the validity of the model, for a variety of reactions. The isobaric threshold is considerably larger (by a factor of 2 to 3) than the production threshold for a given reaction. (auth)

**32306** SIMPLE S AND D NEUTRON GROUND STATE WAVEFUNCTIONS ASSUMING CENTRAL AND $r^{-2}$ TENSOR POTENTIALS. A. F. Nicholson (Philips Electrical Industries, Hendon, Eng.). Australian J. Phys., 15: 169-73 (June 1962).

The coupled wave equations for the S and D parts of the deuteron ground state in the presence of central and tensor forces are shown to reduce to one equation if the tensor potential has an $r^{-2}$ radial dependence. One wavefunction is then a multiple of the other. It is shown that a simple Hulthen wavefunction may be adjusted to give the observed electric quadrupole moment together with a D-state probability having any desired value between 0.1 and 5.6%. (auth)

**32307** BOUND STATES AND SCATTERING IN AN $r^{-2}$ POTENTIAL. A. F. Nicholson (Philips Electrical Industries, Hendon, Eng.). Australian J. Phys., 15: 174-9(June 1962).

The bound-state and scattering wavefunctions for a particle moving in a central $r^{-2}$ potential are investigated. There are no discrete bound states: the discrete states which result when an infinite repulsive core is introduced are specified. The scattering wavefunctions which satisfy physical requirements such as zero net outflow of particles from the scattering region are found. The phase-shifts $\delta_l$ are independent of energy and for large $l$ to go to zero as $(2l + 1)^{-1}$. (auth)

**32308** MASS SINGULARITIES OF FEYNMAN AMPLITUDES. Toichiro Kinoshita (Cornell Univ., Ithaca, N. Y.). J. Math. Phys., 3: 650-77(July-Aug. 1962).

Feynman amplitudes, regarded as functions of masses, exhibit various singularities when masses of internal and external lines are allowed to go to zero. Properties of these mass singularities, which may be defined as pathological solutions of the Landau condition, are studied in detail. A general method is developed that enables a determination to be made of the degree of divergence of unrenormalized Feynman amplitudes at such singularities. It is also applied to the determination of mass dependence of a total transition probability. It is found that although partial transition probabilities may have divergences associated with the vanishing of masses of particles in the final state, they always cancel each other in the calculation of total probability. However, this cancellation is partially destroyed if the charge renormalization is performed in a conventional manner. This result is related to the fact that interacting particles lose their identity when their masses vanish. A new description of state and a new approach to the problem of renormalization seem to be required for a consistent treatment of this limit. (auth)

**32309** SCHRÖDINGER SCATTERING AMPLITUDE. [PART] III. Alex Grossmann (Inst. for Advanced Study, Princeton, N. J.) and Tai Tsun Wu. J. Math. Phys., 3: 684-9(July-Aug. 1962).

A domain of analyticity is obtained for the Schrödinger scattering amplitude minus the first Born term. The connection between the scattering integral equation and the Schrödinger equation is also studied. (auth)

**32310** SPECTRUM OF THE SCATTERING INTEGRAL OPERATOR IN THE PHYSICAL ENERGY SHEET. K. Meetz (Princeton Univ., N. J. and Brookhaven National Lab., Upton, N. Y.). J. Math. Phys., 3: 690-9(July-Aug. 1962). (BNL-5894)

The kernel of the integral equation for the nonrelativistic scattering of a spinless particle by a potential $-\lambda V$ can easily be symmetrized, if V has a definite sign. Under suitable conditions for the potential, the symmetrized kernel is square integrable and generates a completely continuous transformation of the space $L^2$ that has a pure point spectrum. The scattering kernel is a two-valued function of the energy s. For negative real values of s in the first Riemann sheet the kernel is symmetric (Hermitian) and can be spectrally decomposed. Eigenvalues and eigenelements can be analytically continued, at least into the first s sheet and even into the finite second s sheet, if the potential decreases faster than any exponential function for $r \to \infty$. Eigenelements at two complex conjugate points s, $s^*$ form a complete biorthogonal system of $L^2$. The original and the resolvent kernel can be expressed in terms of that system and the eigenvalues, for s in the first and eventually finite second sheet. If the potential is indefinite, the scattering kernel is of polar type for negative real s and can be represented in terms of polar eigenvalues and eigenelements. These may be continued in the same way as for a definite potential. The distribution of eigenvalues in the $\lambda$ plane is studied for arbitrary complex s and related to the occurrence of bound states and resonances. It is shown that Born expansions for resolvent quantities converge, if and only if neither $\lambda V$ nor $-\lambda V$ create bound states. (auth)

**32311** A SYMMETRIC REPRESENTATION FOR THREE-BODY PROBLEMS. I. MOTION IN A PLANE. Felix T. Smith (Stanford Research Inst., Menlo Park, Calif.). J. Math. Phys., 3: 735-48(July-Aug. 1962).

A symmetric representation is sought for the motion of three particles in the limit of weak interaction. Operators with the desired symmetry can be obtained from the 6-dimensional generalized angular momentum tensor. The 4-dimensional problem of motion in a plane is worked out. Symmetric angular coordinates are found, operators and eigenfunctions are constructed, and the coupling coefficients connecting this representation with other representations are discovered. Formally, the eigenfunctions are similar to the symmetric-rotor functions, except for the arguments. (auth)

**32312** THERMODYNAMIC FUNCTIONS OF A FERMI SYSTEM OF DILUTE HARD SPHERES AT TEMPERATURES NEAR ABSOLUTE ZERO. Chen-Ping Yang (Ohio State Univ., Columbus). J. Math. Phys., 3: 797-800(July-Aug. 1962)

The thermodynamic functions of a Fermi system of hard spheres at temperatures near absolute zero are calculated through the evaluation of the coefficient appearing before the second-order term $a^2$, in the fugacity series for the system where a is the hard-sphere diameter. (auth)

**32313** PION-NUCLEON SCATTERING UP TO MEDIUM ENERGIES. A. W. Hendry (Glasgow Univ.). Nuclear Phys., 37: 283-301(Aug. 1962). (In English)

The P- and D-partial wave amplitudes for pion-nucleon scattering are investigated in the s-plane using an approach in which dynamical cuts are replaced by a set of poles. The problem is solved by the single-channel N|D method, and resonances are found to occur in the P-wave $I = 3/2$, $J = 3/2$ and D-wave $I = 1/2$, $J = 3/2$ states. A $\pi\pi$ interaction has only a small effect on the first resonance, but is found to be vital for the second. For energies about the second resonance, an attempt is also made to include explicitly the inelastic $\pi + \pi + N$ channel by treating it phenomenologically as a two-particle system $\pi + N^*$, where $N^*$ is regarded as a particle of intrinsic isobaric spin $3/2$, spin $3/2$, even parity, and mass corresponding to the energy of the first $\pi N$ resonance in the barycentric system. The Born terms for $\pi + N \to \pi + N^*$ are incorporated into the multi-channel N|D method; their effect is to produce an enhancement of the second resonance phase shifts. (auth)

**32314** MESON PRODUCTION ON HEAVY TARGET-NUCLEI AT ENERGIES > $10^{11}$ ev. E. Lohrmann (Deutsches Elektronen-Synchrotron, Hamburg) and M. W. Teucher. Nuovo cimento (10), 25: 957-63(Sept. 1, 1962). (In English)

High-energy nuclear collisions in nuclear emulsions are separated according to the target nucleus involved. The method is applied to 136 collisions with a primary energy $E > 100$ Bev. The mean multiplicity ($N_s$) as a function of the atomic number A of the target nucleus is given for average primary energies of 250 and ≈3000 Bev. The dependence on A and E is in agreement, within the limits of error, with the relation $(N_s) \propto E^{.25}A^{.19}$ predicted by hydrodynamical theory. (auth)

**32315** K-$\mathcal{N}$ SCATTERING IN THE MANDELSTAM REPRESENTATION. I. ANALYTICITY OF THE AMPLITUDE AND THE EFFECT OF BARYON POLE ON $K^- + p \to Y + \pi$ REACTION. S. Iwao (Syracuse Univ., N. Y.). Nuovo cimento (10), 25: 973-94(Sept. 1, 1962). (In English)

Analytic properties of the partial wave amplitude for the $K^- + p \to \Sigma + \pi$ reaction are investigated in the total energy space by making use of the Mandelstam representation. The unitarity condition requires the study of the pion-hyperon as well as the kaon-nucleon scattering. The latter interaction is not important for the long-range part of the interaction, so its effect is neglected. The long-range part of the interaction, arising from single-baryon exchange, can explain the observed low-energy pion-hyperon resonances. The low frequency of the $\Sigma$ hyperon in the $I = 1$, $p_{\frac{1}{2}}$ resonance is interpreted by an accidental cancellation of the long-range potential, so that the universality of the strong pion-baryon interaction holds for the $\Sigma\Sigma\pi$ interaction. The $I = 0$ and $I = 2$, $p_{\frac{1}{2}}$ resonances can be interpreted by the attractive long-range interaction in the pion-hyperon scattering. (auth)

**32316** J = I = 1, VECTOR MESONS AND LOW-ENERGY $\pi$-$\mathcal{N}$ SCATTERING. E. Kazes (Pennsylvania State Univ., University Park). Nuovo cimento (10), 25: 1008-16(Sept. 1, 1962). (In English)

The effect of including a $2\pi$ vector meson interaction into the Chew-Low interaction with pionic rescattering is examined. This model shows negligible corrections on the low-energy $\pi$-$\mathcal{N}$ s and p phase shifts for vector mesons with mass (3.5 to 5.5) $\mu$. A vector meson of mass 4 $\mu$ contributes to the $I = 1/2$ $\pi$-$\mathcal{N}$ cross section (~150 mb) at 650 Mev but does not reproduce its width. (auth)

**32317** PRODUCTION OF ANTIDEUTERONS, LIGHT NUCLEI AND HYPERFRAGMENTS IN HIGH-ENERGY pp-COLLISIONS. R. Hagedorn (CERN, Geneva). Nuovo cimento (10), 25: 1017-37(Sept. 1, 1962). (In English)

Using the statistical theory of particle production, the

partial cross sections for the creation of antideuterons, light nuclei, and hyperfragments are calculated. Rough estimates of multiplicities, center-of-mass energy spectra, and laboratory momentum spectra at several angles are given. (auth)

**32318** ON THE EQUIVALENCE OF DIFFERENT TREATMENTS OF TWO-BODY FINAL-STATE INTERACTIONS. J. D. Jackson (Univ. of Illinois, Urbana). Nuovo cimento (10), 25: 1038-53(Sept. 1, 1962). (In English)

Two methods of handling the strong interaction between a pair of particles involved in some process are shown to be closely equivalent. Within the framework of dispersion relations the two-body interaction is incorporated by keeping the two-body scattering states in the absorptive part. This leads to a form factor involving the scattering phase shifts. In formal scattering theory the interaction effects enter through the two-body scattering cross section, or more correctly, through the wave function of relative motion, or its derivatives, at zero separation of the interacting pair. Through the use of the Jost function the formal scattering theory result is cast into the form of a form factor and the equivalence between the form factor and formal scattering theory results is established. Both nonrelativistic two-body scattering and relativistic (Dirac) scattering are considered for the interacting pair. (auth)

**32319** GHOST SCATTERINGS. Y. Hama, J. Osada, and M. Taketani (Univ. of Sao Paulo, Brazil). Nuovo cimento (10), 25: 1054-60(Sept. 1, 1962). (In English)

It is shown that approximation methods in meson theory sometimes can lead to unexpected virtual phenomena called ghost scatterings, ghost resonances, etc. The calculation of the scattering of a neutral scalar meson in the static limit both by the two-meson Tamm-Dancoff approximation and by the collection of only some special Feynman diagrams is taken as an example. The P-wave scattering phase-shift in the same system with nucleon recoils is also calculated. In each of these calculations, the results are completely different from the exact solution, which can be obtained in these simple cases. (auth)

**32320** NUCLEON-NUCLEON INTERACTION AND THE QUANTUM NUMBERS OF THE $\zeta$-MESON. D. B. Lichtenberg (Michigan State Univ., East Lansing). Nuovo cimento (10), 25: 1106-12(Sept. 1, 1962). (In English)

It is shown that the assignments isospin T = 1, spin J = 0, parity P = +, and G-parity G = − for the $\zeta$ meson are not ruled out by experiment. It is pointed out that with these quantum numbers, the $\zeta$ could account qualitatively for certain features of the nucleon-nucleon interaction in a simple way. (auth)

**32321** PRODUCTION OF PION PAIRS IN PION-NUCLEUS COLLISIONS AND $\pi$-$\pi$ RESONANCES. M. Ademollo and C. Chiuderi (Università, Florence and Scuola di Perfezionamento in Fisica, Florence). Nuovo cimento (10), 25: 1113-18(Sept. 1, 1962). (In English)

Double pion production in peripheral collisions between pions and nuclei is discussed, in the hypothesis that two of three final pions are in the J = 1, I = 1 resonance state. The cross section is calculated and numerical results are given for incident pion energies of 2.8 and 14 Bev. Assuming that the transferred four-momentum $\Delta$ is less than $3m_\pi$, the total cross sections are in both cases around 8 mb for a mass number A = 95. (auth)

**32322** ON THE APPLICATION OF GLASER'S RESULTS TO STUDY ANALYTICITY PROPERTIES OF PHYSICAL AMPLITUDES. R. Ascoli (Università, Turin and Istituto Nazionale di Fisica Nucleare, Turin). Nuovo cimento (10), 25: 1119-34(Sept. 1, 1962). (In English)

A particular solution to some problems of analytic completion is considered, and its application to the retarded and advanced functions of local quantum field theory is studied. This application provides a very general method for studying analyticity properties of these functions (at least in the case of products of more than two operators). Attention is concentrated on the question whether in this way analyticity properties on the mass shell may be obtained for physical amplitudes. Cases where analyticity properties on the mass shell are proved are surveyed. It appears that in these proofs, besides the assumption of the existence of the vacuum expectation values of the retarded products, some further assumptions or arguments concerning the behavior at the boundary of the analyticity region are needed. This investigation leads to the conclusion that this same difficulty of reaching the mass shell is present in the method under study, except in the case of the vertex function; the only notable case in which the boundary of the analyticity region may reach the mass shell is the vacuum expectation value of the product of four-operators representing the $\pi$-$\pi$ scattering amplitude. (auth)

**32323** REMARKS ON THE LIMIT $Z_3 \to 0$. J. S. Dowker (Univ. of Pennsylvania, Philadelphia). Nuovo cimento (10), 25: 1135-40(Sept 1, 1962). (In English)

In the Zachariasen (Phys. Rev., 121: 1851(1961)) field theory it is shown that when $Z_3 = 0$, the A particle can be considered bound. It is shown that in the ultra-nonrelativistic limit the theory goes over into a potential theory with the potential singular at the origin. (auth)

**32324** A FORMULATION FOR THE BOUND-STATE PROBLEMS. H. Ezawa, K. Kikkawa, and H. Umezawa (Tokyo Univ.). Nuovo cimento (10), 25: 1141-66(Sept. 1, 1962). (In English)

A theory is proposed for a bound system, including composite particles. Presuming that the outgoing operator $A^{out}(x)$ of the elementary particle A is known as a series in powers of the operators at t = 0, A(x,0) and $\dot{A}(x,0)$, it is shown that the commutation relations among the outgoing operators of elementary and composite particles give all the information about the composite particles. (auth)

**32325** THE FOUR-POINT FUNCTION FOR A NON-LINEAR TWO-COMPONENT FIELD, AND ITS CONNECTIONS WITH HEISENBERG'S THEORY OF ELEMENTARY PARTICLES. E. Montaldi (Università, Milan and Istituto Nazionale di Fisica Nucleare, Milan). Nuovo cimento (10), 25: 1167-82(Sept. 1, 1962). (In English)

The theory of the four-point function for a two-component field is developed, satisfying a nonlinear equation that is a simplified form of the basic equation of Heisenberg's theory of elementary particles, in its formulation by means of isospinors. The underlying Pauli algebra permits the achievement of a remarkable compactness of the final results; moreover, the physical interpretation of these results turns out to be quite clear as compared with the scheme based on the usual formulation of Heisenberg's theory. In particular, the connection with the two-point function and the "regularization conditions" (following from the differential equation) are investigated. (auth)

**32326** SEMI-CLASSICAL LIMITS OF DIRAC'S EQUATION. Marius Kolsrud (Univ. of Oslo). Phys. Norvegica, 1: 27-31(1962). (In English)

By unitary transformations the Dirac equation for a particle in an electromagnetic field is put into forms which are closely related to the classical relativistic Hamilton-Jacobi

equation. An expansion in terms of $\hbar$ is made. The first order terms, containing the spin-interactions, are given explicitly. (auth)

**32327** ON THE ANOMALOUS THRESHOLD AND COMPOSITE PARTICLES. Tetsuo Sawada (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 27: 882-98(May 1962). (In English)

Using the equal-time Bethe-Salpeter amplitude, the form factor of the charge distribution of composite particles and its threshold are shown to be closely related to those given by the phenomenological quantum field theory. When the Bethe-Salpeter amplitude describes a bound state, its normalization condition can be used to determine the effective coupling constants of interactions between the composite particle and its constituents. In this way, a relation can be derived among the effective coupling constants, even if no detailed information is possessed on the force binding the constituent particles. To examine this relation in experiments gives a way for judging whether the particles are composite or not. (auth)

**32328** SECOND QUANTIZATION AND LORENTZ INVARIANCE. [PART] II. Shigeo Sato (Rikkyo Univ., Tokyo). Progr. Theoret. Phys., (Kyoto), 27: 936-48(May 1962). (In English)

The expansion of the hamiltonian in $1/c^2$, which may be used to get the general form of the covariant Hamiltonian for a system of a fixed number of particles, is applied to a second-quantized system to obtain a convergent and covariant hamiltonian formalism. In this case, it is shown that if the interaction terms are commutable with $\Sigma m_i N_i$, where $m_i$'s and $N_i$'s are masses and number operators of concerned particles, the expansion in $1/c^2$ can be performed. As a result, a possible method to construct a hamiltonian formalism for the second quantized system is obtained. Moreover, if some suitable relation exists between concerned masses, the interchange of particles can be treated to some extent. An example is given to clarify this method. The method can not be applied to the case where a massless particle is involved. A tentative method for such a case is proposed, comprising expansion of the hamiltonian in 1/c. The relation between spin and statistics is discussed. (auth)

**32329** NOTE ON UNITARY SYMMETRY IN STRONG INTERACTIONS. Susumu Okubo (Tokyo Univ. and Univ. of Rochester, N. Y.). Progr. Theoret. Phys. (Kyoto), 27: 949-66(May 1962). (In English)

Assuming invariance of a theory under three-dimensional unitary group, various consequences are investigated. Both the Sakata and Gell-Mann schemes can be treated in this fashion in a simple way. A mass formula for particles belonging to the same irreducible representation is derived and compared with experiments. (auth)

**32330** EFFECT OF PION-PION SCATTERING RESONANCE ON NUCLEON STRUCTURE AND PION-NUCLEON SCATTERING AT LOW ENERGIES. Atsushi Takahashi (Tohoku Univ., Sendai). Progr. Theoret. Phys. (Kyoto), 27: 988-98(May 1962). (In English)

The effect of pion-pion scattering resonances on the isovector part of the nucleon structure is analyzed. A subtraction is performed for dispersion relations on helicity amplitudes of the nucleon-antinucleon production process in order to remedy the divergence regarding the left-hand cut. If the subtracted spectral representations are used for the form factors, and a narrow resonance is assumed for the P-wave pion-pion scattering, then the form factors can be written in a particular form and the square of the pion-pion scattering resonance energy is required to be 18 to $25\mu^2$. The effect of this resonance on pion-nucleon scattering at low energies is shown to be not inconsistent with the experimental data, if the subtracted form is used for the pion-pion terms in the dispersion relations for pion-nucleon scattering amplitudes. (auth)

**32331** ON A MODEL OF NUCLEON STRUCTURE AND MESON-NUCLEON INTERACTION. [PART] III. Reijiro Kubo and Hiroshi Nakamura (Tokyo Inst. of Tech.). Progr. Theoret. Phys. (Kyoto), 27: 1013-24(May 1962). (In English)

The electromagnetic structure of the nucleon is studied by means of dispersion theory, assuming that the $\pi$-$\pi$ resonance arises as a kinematical result of the $\rho$ meson. It is shown that Im $F_1(t)$ ($F_1$ = the isovector part of the form factors of the $\gamma$-nucleon vertex) has one or two zero points in general in the representation considered that do not appear in the dynamical theory. Using this representation, the ratios of the $\rho$-nucleon and $\rho$-$\pi$ coupling constants are estimated from the experimental values of the form factors. The results are consistent with several models, which are discussed. (auth)

**32332** THE OBSERVABLES AND LOCALIZED STATES OF A DIRAC PARTICLE. P. M. Mathews and A. Sankaranaryanan (Univ. of Madras). Progr. Theoret. Phys. (Kyoto), 27: 1063-7(May 1962). (In English)

It is shown that for a nonzero-mass Dirac particle, only one of four position operators derived by Mathews and Sankaranaryanan (Progr. Theoret. Phys. (Kyoto), 26: 499 (1961)) has eigenstates (describing the localized states of the particle) that obey a certain regularity condition. However, this condition is not applicable to the states of a particle with zero rest mass, and in such a case the multiplicity of possible position (and other) operators persists. (auth)

**32333** NOTE ON HYPERON ISOBARS. Shigeo Minami (Osaka City Univ.). Progr. Theoret. Phys. (Kyoto), 27: 1068-9(May 1962). (In English)

Suggestions are given concerning: verification of the existence of the $Y_0^*$ and $Y_2^*$ $\Sigma$-$\pi$ resonances and the $Y_1^*$ $\Lambda$-$\pi$ resonance by analysis of single and double pion production in $\Sigma$-nucleon interactions; and determination of the spin of the $Y^*$ particles by analysis of double pion production in $\Sigma$-nucleon interactions and of single pion production in $\pi$-proton interactions. (T.F.H.)

**32334** ON $\bar{K}$-N INTERACTIONS AND A POSSIBLE MAXIMUM OF CROSS SECTIONS FOR PION REACTIONS. Shigeo Minami (Osaka City Univ.). Progr. Theoret. Phys. (Kyoto), 27: 1071-3(May 1962). (In English)

It is assumed that the 400-Mev/c resonance in the $K^-$-p scattering cross section is connected with the threshold of the reaction $K^- + p \rightarrow Y_1^* + \pi$. It is shown that if resonances analogous to the $K^-$-p resonances occur in the $\pi$-N and $\gamma$-$\pi$ cross sections, these resonances should occur at energies of 385 and 535 Mev respectively, and should correspond to thresholds of the reactions $\pi + N \rightarrow N^* + \pi$ and $\gamma + N \rightarrow N^* + \pi$, respectively. The intrinsic properties of the resonances considered are discussed. (T.F.H.)

**32335** HEAVY MESONS AND PARTICLE MIXTURE THEORY. Shigeo Minami (Osaka City Univ.). Progr. Theoret. Phys. (Kyoto), 27: 1075-7(May 1962). (In English)

A model is suggested for the reaction $\pi^+ + p \rightarrow N + \xi$, and it is shown that experimental results on the $\eta$, $\omega$, $\rho$, and $\zeta$ mesons can be explained to some extent by the particle-mixture theory. (T.F.H.)

**32336** THE REGULARITIES OF MASS LEVELS OF BARYONS AND MESONS. Ken-iti Matumoto (Kyoto Univ.).

Progr. Theoret. Phys. (Kyoto), 27: 1079-80(May 1962). (In English)

Simple equations are found relating the masses of groups of unstable particles, viz. $m_\Sigma \approx m_\Lambda + \frac{1}{2}m_\pi \approx m_N + \frac{1}{2}m_K$, etc. These equations are arranged into a group for baryons having strangeness (S) = −1 (subdivided into groups having I = 0 and 1); a group for baryons having S = 0 (subdivided into groups having I = ½ and ³⁄₂); and a group for mesons. The regularities in the series of equations suggest the existence of several as-yet-unobserved particles, and cast doubt on the existence of other particles. (T.F.H.)

**32337** A REMARK ON THE ANOMALOUS MAGNETIC MOMENT OF THE HYPERONS. Jugoro Iizuka (Tokyo Univ. of Education). Progr. Theoret. Phys. (Kyoto), 27: 1080-2 (May 1962). (In English)

Assuming the anomalous magnetic moment of the Λ hyperon ($\mu_\Lambda$) to be given, and the Σ hyperon to be composed of a Λ nucleus orbited by a π meson, it is shown that in the limit the angular momentum of the pion = 0, $\mu_\Lambda = \mu_{\Sigma^+} = \mu_{\Sigma^-} = \mu_{\Sigma^0}$. It is supposed that the only corrections to this equality must arise from Λ-2π configurations, which are assumed to be rare compared with Λ-π configurations. Correction terms are calculated. (T.F.H.)

**32338** MASS FORMULA FOR RESONANCE STATES. Yasuhisa Katayama (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 27: 1083-4(May 1962). (In English)

A formula is given relating the mass of a resonance particle to its angular momentum, isospin, baryon number, and strangeness. The formula is combined with certain selection rules in order to analyze the masses of groups of particles having a given angular momentum. (T.F.H.)

**32339** SHAPE OF THE ANGULAR DISTRIBUTION OF SHOWER PARTICLES. I. V. Rechitskii and V. M. Chudakov (Inst. of Physics and Tech, Academy of Sciences, Uzbek SSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 454-8(Aug. 1962). (In Russian)

A new quantitative criterion is proposed for investigation of the angular distribution of shower particles in photographic emulsions. By applying the criterion it is shown that for the primary nucleon energies of the order of ~$10^{11}$ ev the distribution in the quantity $x = \lg\operatorname{tg}\theta$ is not a normal one and is in qualitative accordance with the predictions of the two-center model. (auth)

**32340** CONTRIBUTION OF SPACE-LIKE INTERVALS IN THE S-MATRIX. L. V. Prokhorov (Leningrad State Univ.). Zhur. Eksptl'. i Teoret. Fiz., 43: 476-82(Aug. 1962). (In Russian)

It is proved that the usual asymptotic condition in the theory of quantized fields can be written down in a form which is equivalent to the statement that the space-like regions outside the cones of family (1) do not contribute to the S-Matrix. The asymptotic condition thus formulated makes it possible to set up a relativistically invariant scattering formalism for nonlocal fields which is analogous to the local field theory formalism. (auth)

**32341** FLUCTUATIONS OF NUMBER OF PARTICLES IN AN ELECTRON-PHOTON SHOWER. N. M. Gerasimova (Lebedev Inst. of Physics, Moscow). Zhur. Eksptl'. i Teoret. Fiz., 43: 500-8(Aug. 1962). (In Russian)

Equations for the mean square number of particles in an electron-photon shower are derived. The solution is obtained in an analytical form by neglecting ionization losses at sufficiently large depths. The formulas can be used to study the fluctuation pattern in electron-photon showers. (auth)

**32342** DETERMINATION OF THE PARITY AND σ-HYPERON K-MESON COUPLING CONSTANT. Ya. I. Granovskii and V. N. Starikov (Inst. of Nuclear Physics, Academy of Sciences, Kazakh SSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 525-9(Aug. 1962). (In Russian)

With help of the experimental data on K-meson scattering on neutrons and the dispersion relations for forward scattering, it is shown that the Σ parity relative to the K-p system is negative and $g_\Sigma^2/4\pi = 10 \pm 4$. (auth)

**32343** INTERACTION CROSS SECTIONS FOR VIRTUAL PARTICLES. I. M. Dremin and D. S. Chernavskii (Lebedev Inst. of Physics, Moscow). Zhur. Eksptl'. i Teoret. Fiz., 43: 551-6(Aug. 1962). (In Russian)

Inelastic interaction of high energy nucleons is considered in the one-meson approximation. The nucleon interaction cross section $\sigma_{NN}(s)$ depends on $\sigma(s_1,k^2)$, the total cross section for interaction between a virtual π meson and a nucleon ($s_1$ is the square of energy in their cms and k is the 4-momentum of the virtual meson $k^2 \neq -\mu^2$). It is found that $\sigma(s_1,k^2)$ should be a decreasing function of the variables $s_1$ and $k^2$. The form of the function $\sigma(s_1,k^2)$, which satisfies the conditions that $\sigma_{NN}$ and $\sigma(s_1,k^2=-\mu^2)$ are constant at high energies and satisfy the analyticity conditions for $\sigma(s_1,k^2)$ [12], is presented. The consequences of such a form of function $\sigma(s_1,k^2)$ and in particular the asymptotic (for $s \to \infty$) behavior of the nucleon elastic scattering amplitude as a function of the Mandelstam variables s and t are discussed. The latter are found to agree with Gribov's result. (auth)

**32344** BEHAVIOR OF LOW ENERGY $\mu^+$-MESONS IN ORGANIC SUBSTANCES. B. M. Smirnov and Yu. M. Ivanov. Zhur. Eksptl'. i Teoret. Fiz., 43: 557-60(Aug. 1962). (In Russian)

The cross section for inelastic scattering of muonium on vibrational levels of the hydrogen molecule is estimated. It is found that the slowing-down time of a $\mu^+$ in organic substances after formation of muonium is of the same order of magnitude as the depolarization time of the meson in muonium. The possibility of charge exchange of a $\mu^+$ into a molecule is discussed. It is shown that in molecular hydrogen not all (but nevertheless a significant part) of $\mu^+$ mesons are involved in the molecule as a result of charge exchange. In agreement with the experimental data in organic substances all $\mu^+$ decay in the molecules. (auth)

**32345** SOME CONSIDERATIONS IN FAVOR OF THE EXISTENCE OF A SCALAR NEUTRAL MESON. V. I. Kushtan (Uzhgorodskii State Univ., USSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 581-3(Aug. 1962). (In Russian)

Experimental data on $\pi^-$-p scattering are treated by extrapolating to the nonphysical pole, the presence of which is connected with the existence of a scalar neutral meson. The results of the processing of the data apparently indicate the existence of a scalar neutral meson. It is shown that the most probable value of the mass of this meson is $380 \pm m_e$. (auth)

**32346** ASYMPTOTIC BEHAVIOR OF CHARGED PARTICLE WAVE FUNCTIONS. R. K. Peterkop (Inst. of Physics, Academy of Sciences, Latvian SSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 616-18(Aug. 1962). (In Russian)

Distortion of the scattered wave phase shift is determined for nonrelativistic reaction channels with an arbitrary number of charged particles. (auth)

**32347** APPLICATION OF THE DISPERSION RELATIONS FOR CALCULATING THE ELECTRON MAGNETIC MOMENT. M. V. Terentev. Zhur. Eksptl'. i Teoret. Fiz., 43: 619-36(Aug. 1962). (In Russian)

Calculation of a correction of the order of $\alpha^2$ to the electron magnetic moment is performed by applying the uni-

tarity relation for the scattering matrix and the dispersion relations for the magnetic form-factor. The amount of calculations is somewhat smaller than if the usual Feynman technique is employed. The value $-0{,}328\alpha^2/\pi^2$ obtained for the correction is the same as that obtained by Sommerfield. (auth)

**32348** A VARIATIONAL METHOD FOR CONSTRUCTING THE POLARIZATION POTENTIAL IN COLLISION THEORY. V. D. Obedkov (Leningrad State Univ.). Zhur. Eksptl'. i Teoret. Fiz., 43: 649-54(Aug. 1962). (In Russian)

A suitable variational principle is employed for setting up the adiabatic polarization potential in collision theory for electrons and atoms. As an example the dipole part of the polarization interaction between electrons and hydrogen and helium atoms in the ground state is derived and the applicability of the adiabatic approximation for constructing the exchange polarization potential is considered. (auth)

**32349** ON A CERTAIN POSSIBILITY OF APPLYING THE PAULI-VILLARS REGULARIZATION. V. S. Vanyashin (Dnepropetrosk State Univ., USSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 689-91(Aug. 1962). (In Russian)

For renormalizing the vector boson interactions it is suggested that the Pauli-Villars regularization be employed in which the longitudinal part of the vector field plays the role of the compensating field. (auth)

**32350** PHASE SHIFT ANALYSIS OF NUCLEON-NUCLEON SCATTERING AT 210 Mev. Yu. M. Kazarinov and I. N. Silin (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur Eksptl'. i Teoret. Fiz., 43: 692-701(Aug. 1962). (In Russian)

Phase shift analysis of n-p and p-p scattering data is carried out simultaneously. Two phase shift sets are chosen from the solutions obtained. Upon extrapolation to 310 Mev they correspond to sets 1 and 2 found by Stapp et al. by making a phase shift analysis of p-p scattering data at 310 Mev. (auth)

**32351** NOTE ON THE PROPERTIES OF K-MESON PAIRS. V. I. Ogievetskii, E. O. Okonov, and M. I. Podgoretskii (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 720-3(Aug. 1962). (In Russian)

Some peculiarities of K-meson pair production and decay are considered. It is shown that the type of decay is determined by the parity of the orbital momentum in the $K^0\overline{K}^0$ system. (auth)

**32352** ANGULAR DISTRIBUTION OF ELECTRONS IN $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ DECAY. I. I. Gurevich and B. A. Nikol'skii (Inst. of Nuclear Energy, Academy of Sciences, USSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 724-5(Aug. 1962). (In Russian)

The theoretical angular distribution in $\pi \rightarrow \mu \rightarrow e$ decay, described by $dN/d\omega \sim (1 - a \cos \vartheta)$ (where $a = {}^1/_3$), was correlated with experimental measurements on 100,380 electron emissions in $\pi \rightarrow \mu \rightarrow e$ decay in emulsions. The data were obtained by developing measurements of electron angular distributions in $\mu \rightarrow e$ decay in the longitudinal direction. (R.V.J.)

**32353** EXPERIMENTAL DATA ON NEW PION RESONANCES. Ya. Ya. Shalamov and A. F. Grashin (Inst. of Theoretical and Experimental Physics, Academy of Sciences, USSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 726-8 (Aug. 1962). (In Russian)

Xenon and propane 17-liter bubble chambers were used in investigations of 1) $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ reactions on free and quasi-free protons at $\pi^-$ energy $p_0 = 2.8$ Bev/c. Total mass distribution diagrams were constructed for 170 events of $\pi^0$ production at $p_0 = 2.8$ Bev and $p_0 = 7.2$ Bev in xenon-propane mixtures and for 2) $\pi^- + n \rightarrow \pi^- + \pi^- + p$ on quasi-free neutrons in freon. The first reaction was also studied in freon ($C_2F_3Cl_3$) at $p_0 = 2.8$ Mev/c. 228 selected events of $\pi^- + (A,Z) \rightarrow \pi^- + p + m\gamma + (A,Z)'$ (m = 1 with stopped protons) showed that the bipion mass spectrum; with Q = −2 charge, I = 2; practically coincides with the Q = −1 spectrum. The resonance peaks for the second reaction were found at energies $M_{\pi\pi} \approx 0.59$, 0.78, 0.98, and 1.2 Mev. (R.V.J.)

**32354** MEAN LIVES OF POSITRONS IN AQUEOUS SOLUTIONS. Jerome E. Jackson and John D. McGervey (Western Reserve Univ., Cleveland). Prepublication Copy. 15p.

By measurement of the time distribution of positron annihilations in aqueous solutions, reaction rates for oxidation of positronium by the ions $MnO_4^-$, $IO_3^-$, and $Hg^{2+}$ were determined. In strong oxidizing solutions the mean life of the positrons reaches a lower limit of $4.3 \times 10^{-10}$ sec; the short lifetime $\tau_1$ in water was measured and found to agree with this value. A $Pb(ClO_4)_2 \cdot 3H_2O$ solution reduced the intensity $I_2$ with no significant change in the long mean life $\tau_2$, an effect previously observed in nitrate solutions. This may mean that in these two cases oxidation can occur before positronium is thermalized but not afterwards. The decay distributions from a mixture of $Hg^{2+}$ and $MnO_4^-$ ions in solution and the $Hg^{2+}$ ion in separate solutions with $Cl^-$ and $ClO_4^-$ indicated an association taking place between the negative and positive ions. (auth)

## Neutron Physics

**32355** (AERE-R-3920) A REVIEW OF HIGH INTENSITY NEUTRON SOURCES AND THEIR APPLICATION IN INDUSTRY. G. Olive, J. F. Cameron, and C. G. Clayton (United Kingdom Atomic Energy Authority. Research Group. Wantage Research Lab., Wantage, Berks, England). June 1962. 43p.

Various high intensity neutron sources which are now available are reviewed and their present and future applications in industry are discussed. The characteristics and cost of radioisotope neutron sources are compared with accelerating machines, and it is shown that, for large scale applications of activation analysis and short lived isotope production where a high neutron flux is required, the neutron generator is preferred. There are four useful reactions by which the neutrons are available from accelerating machines; these are the X-Be, d-Be, d-d, and d-t (where x is x-ray). The characteristics of each type of machine are discussed, and, although the characteristics and life of the tritiated titanium target are known to be restricted, it is concluded that for industrial application the (d,t) reaction is the most useful and is likely to remain so in the future. Low cost and maintenance are the chief advantages. The most important industrial application is considered to be activation analysis by fast and thermal reactions with the possibility of extension to process control. The design of an irradiation facility suitable for use in an industrial analytical laboratory is discussed. (auth)

**32356** (CEA-Note-345) ETUDE SUR LES ACCELERATEURS DEPARTICULES, DU TYPE TRANSPORTABLE, UTILISES EN TANT QUE SOURCES DE NEUTRONS. I. INTRODUCTINN. II. APPLICATIONS A L'ANALYSE QUALITATIVE ET QUANTITATIVE (lère partie). (Study

of Transportable Type-Particle Accelerators, Utilized as Neutron Sources. I. Introduction. II. Application to Qualitative and Quantitative Analysis (1st. Part)). S. Godar (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucleaire, Saclay). 1962. 71p.

A bibliographic study is being made on transportable particle accelerators used as neutron sources. In the first report of this bibliographic study, the applications of such accelerators to qualitative and quantitative analysis are considered. As an introduction, the interactions of neutrons with matter are described. Then, the transmission of thermal neutrons, transmission of neutrons having energy higher than the thermal level, absorption in a neutron flux, activation by neutrons, charged particles, and photons are reviewed. (J.S.R.)

**32357** (GA-3122) NEUTRON THERMALIZATION À LA MODE. Mark Nelkin (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Apr. 25, 1962. Contract AT(04-3)-167. 17p.

Development of the theory of neutron thermalization for use in solving the transport equation is discussed. Results of studies of the basic mathematical properties of the transport equation for thermal neutrons are described. The definition of the thermal diffusion length as an eigenvalue problem and the numerical solution of this equation with comparison to experiment are discussed. The question of existence of an eigenvalue representing an asymptotic exponential decay is considered. (M.C.G.)

**32358** (GEAP-3644) VARI-II. J. L. Russell, Jr. (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). Mar. 10, 1961. Contract AT(04-3)-189. 28p.

The VARI-II program was developed for analyzing the results of an absorber burn-up experiment. The experiment consists of measuring the effective cross section of small samples of materials subjected to neutron irradiation. The calculational model allows for self-shielding of the sample with respect to the flux monitor, variation of the reactor power with time, and the transmutation of any isotope being considered to any other isotope by either neutron capture or a decay process. The problem is solved by a fourth order marching procedure which uses the continuously up-dated self-shielding factor to recalculate the transfer matrix at each step. Equations, input, output, and operation are discussed. (M.C.G.)

**32359** (GEAP-3944) CALCULATED SCATTERING KERNELS FOR LIGHT WATER AT 23°C, 42°C, 61°C, AND 82°C. B. A. Kerr (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). May 27, 1962. Contract AT(04-3)-189. 151p.

A listing of the bound-proton kernels for neutron scattering, calculated in conjunction with the USAEC Control Rod Materials Program, is presented. (auth)

**32360** (IA-757) THE MEAN NUMBER OF NEUTRONS PER FISSION FROM MASS-DISTRIBUTION OF FISSION FRAGMENTS. M. Sieger and S. Yiftah (Israel. Atomic Energy Commission, Tel Aviv). July 1962. 12p.

For the case of binary asymmetric fission, when the chain-yield of each mass number is measured with a relative standard error $\epsilon$, the average number of released neutrons in the fission process, $\overline{\nu}$, can be determined from these chain-yields with a standard error $\Delta\overline{\nu} \approx 1.35\,\epsilon$ neutrons. The relative weight of the mass numbers as regards their contribution to the total $\Delta\overline{\nu}$ was plotted. It was concluded that not more than 40 certain chain-yields need be spectrometrically determined, in order to arrive at an accuracy of $\Delta\overline{\nu} \approx 0.04$ neutrons. In addition, some $\overline{\nu}$ values were calculated from mass-distributions. These are compared with other published values obtained similarly. (auth)

**32361** (IA-761) NUMERICAL DISCRETE Sn SOLUTION OF NEUTRON TRANSPORT PROBLEMS ON THE PHILCO 2000 COMPUTER. S. Yiftah, L. Gitter, M. Szac, and Y. Ilamed-Lehrer (Israel. Atomic Energy Commission, Tel Aviv). July 1962. 46p.

A TAC language program, the DSN-TAC Code, was prepared for the Philco Transac S-2000 computer. The code computes the solution of the neutron transport equation for the case of spherical geometry, isotropic scattering, and discrete energy levels. The development of the different equations and procedures to arrive at the solutions are treated in some detail. The DSN-TAC was used for the calculation of several experimental critical assemblies. (auth)

**32362** (MITNE-17) MEASUREMENTS OF THE SPATIAL AND ENERGY DISTRIBUTION OF THERMAL NEUTRONS IN URANIUM, HEAVY WATER LATTICES. P. S. Brown, T. J. Thompson, I. Kaplan, and A. E. Profio (Massachusetts Inst. of Tech., Cambridge). Aug. 20, 1962. Contract AT(30-1)-2344. 224p. (NYO-10205)

Intracell activity distributions were measured in three natural U, heavy water lattices of 1.010 in. dia., Al clad rods on triangular spacings of 4.5 in., 5.0 in., and 5.75 in., respectively, and in a U, heavy water lattice of 0.25 in., 1.03% $U^{235}$, Al-clad rods on a triangular spacing of 1.25 in. The distributions were measured with bare and Cd-covered foils of Au, Lu, and Eu. The Au was used as a 1/v absorber to measure the thermal neutron density distribution. Because the activation cross sections of Lu and Eu depart considerably from 1/v behavior, their activation depends strongly on the thermal neutron energy spectrum. Hence, they were used to make integral measurements of the change in the neutron energy spectrum with position in the lattice cell. A method was developed for treating the partial absorption, by Cd covers, of neutrons at the 0.46 ev Eu resonance, and it was found possible to correct the Eu activations to energy cutoffs just above and just below the resonance. The measured activity distributions were compared with those computed with the THERMOS code. In the natural U lattices, THERMOS gave excellent agreement with the measured Au activity distributions and very good agreement with the Lu and Eu distributions, indicating that THERMOS gives a good estimate of the spatial and energy distribution of thermal neutrons in these lattices. In the enriched lattice, THERMOS gave a large overestimate of the activity dip in the fuel for all three detectors. The discrepancy was attributed to a breakdown in the Wigner-Seitz cylindrical cell approximation at small cell radii. However, the measured ratios of Lu and Eu activity to Au activity were in good agreement with the THERMOS values, indicating that THERMOS gave a good estimate of the degree of spectral hardening. Neutron temperature calculations were made from the data by using Westcott effective cross sections. The temperature changes so calculated agreed well with those predicted by THERMOS. Disadvantage factors calculated by the Amouyal-Benoist-Horowitz (ABH) method were in excellent agreement with the measured values in the natural U lattices. The agreement was not as good in the enriched lattice because of an expected breakdown in the ABH method at small cell radii. Values of the thermal utilization obtained from experiment, from THERMOS, and with the ABH method were in excellent agreement for all the lattices studied. Radial and axial buckling measurements made with Lu were in excellent agreement with similar measurements made with Au, indicating that the

thermal neutron spectrum was uniform throughout the lattice tank. Measurements of intracell Au activity distributions made in off-center cells differed only slightly from those made in the central cell of the lattice, indicating that the radial flux distribution was almost completely separable into a macroscopic $J_0$ and a microscopic cell distribution. (auth)

**32363** (ORNL-3338) THE EFFECT OF PROMPT NEUTRONS ON THE DIRECTION AND TIME OF FLIGHT OF FISSION FRAGMENTS. R. W. Lide (Oak Ridge National Lab., Tenn.). Oct. 9, 1962. Contract W-7405-eng-26. 82p.

Calculations were made of the effect of prompt neutrons on the deflection and time of flight of fission fragments. This was done as an aid to the analysis of data from fission experiments using time-of-flight techniques. Assuming that the energy distribution function of prompt neutrons is that given by Watt, an expression is obtained for the probability distribution in the angle between the final velocities of the two fragments as a function of the number of prompt neutrons emitted and the masses of the fragments. Under the same assumption, it is shown that the probability distribution for the flight time of a given fragment over a given flight path is very nearly Gaussian. This distribution is (to a close approximation) centered about the flight time for no neutron emission with a variance which depends on the number of neutrons emitted and the mass of the fragment. (auth)

**32364** (TID-16691) CALCULATION OF THE INELASTIC SCATTERING OF NEUTRONS FROM POLYETHYLENE AND WATER. D. T. Goldman and F. D. Federighi (Knolls Atomic Power Lab., Schenectady, N. Y.). [1962]. Contract [W-31-109-eng-52]. 26p.

Calculation of the inelastic scattering process in polyethylene and water is presented, and the necessity for using a proper model of scattering in the calculation of reactor fluxes is illustrated. A summary of the modified Nelkin water model is also given together with some comparisons of predicted scattering cross sections with experimental data. A method for the calculation of neutron fluxes is outlined and comparisons of theory and experiments are presented. (P.C.H.)

**32365** (WAPD-TM-207) CLIP 1—AN IBM-704 PROGRAM TO SOLVE THE P-3 EQUATIONS IN CYLINDRICAL GEOMETRY. B. Anderson, J. Davis, E. Gelbard, P. Jarvis, and J. Pearson (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). May 1962. Contract AT-11-1-GEN-14. 18p.

A second order form of the cylindrical P-3 equations is obtained for the case of an isotropic source. The boundary conditions and numerical method are discussed. Input preparation and operating instructions are included. (auth)

**32366** SCATTERING OF POLARIZED NEUTRONS BY SPIN WAVES IN MAGNETITE. G. A. Ferguson, Jr. and A. W. Saenz (U. S. Naval Research Lab., Washington, D. C.). Phys. and Chem. Solids, 23: 117-21(Jan.-Feb. 1962). (In English)

The one-magnon zero-phonon scattering of polarized 1.13 Å neutrons by acoustic spin waves was measured in the neighborhood of the (111) reflection of a magnetite crystal at 204°C. Qualitative confirmation was obtained for theoretical predictions of the dependence of this scattering on the incident neutron polarization. (auth)

**32367** FREQUENCY SPECTRUM OF LIQUIDS AND COLD NEUTRON SCATTERING. K. S. Singwi, A. Sjoelander, and A. Rahman (Argonne National Lab., Ill.). IAEA Preprint No. SM-30/43. 13p. (TID-16830)

To be Published in IAEA Proceedings of the Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, held in Chalk River, Canada, 10–14 September 1962.

A question which arises in connection with slow neutron scattering by liquids is: does there exist a frequency spectrum for liquids analogous to that in solids? The answer to this question is given by showing that the width function $\gamma(t)$ of the Gaussian space-time self-correlation function $G(\vec{r},t)$ can be expressed, by using the frequency spectrum of the velocity auto-correlation function, in a form which is formally identical with that of a harmonic solid. Thus a knowledge of the frequency spectrum of the velocity autocorrelation function should allow calculation of slow neutron scattering by liquids as has been emphasized by Egelstaff and co-workers. Using a stochastic model of a liquid, the frequency spectrum $f(\omega)$ of the velocity autocorrelation function is calculated for water at 300°K and for liquid lead at 620°K. In the case of water a maximum in $f(\omega)$ corresponding to $\eta\omega$ = 75°K is predicted. For Pb the maximum also occurs at nearly the same $\omega$-value. There also occurs a minimum in $f(\omega)$ in both cases. Larsson and Dahlborg have observed a maximum in $f(\omega)$ at the above predicted $\omega$-value. A recent observation in liquid lead of Cotter et al. probably confirms our prediction too. (auth)

**32368** SYSTEMATIC STUDY ON TOTAL NEUTRON SCATTERING CROSS SECTIONS OF HYDROGEN CONTAINING MOLECULES. J. Janik, J. A. Janik, F. Maniawski, H. Rzany, Z. Rogalska, J. Sciesinski, U. Sagan, and N. Tubbs (Inst. of Nuclear Physics, Krakow). IAEA Preprint No. SM-30/13. 10p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

Results of total scattering cross-section measurements for $NH_3$, $H_2S$ (gases), and $CH_4$ (liquid) were obtained. The results for gases were compared with the theory of Krieger and Nelkin. The same comparison in the case of liquid $CH_4$ led to the conclusion that $CH_4$ molecules rotate freely in the liquid state. Measurements of the scattering cross-sections of $CH_3SH$ molecules in the gaseous and liquid state were also performed. The results do not confirm the previously reported data, i.e. they do not show any existence of peaks connected with the hindered internal rotation. However, a comparison with the theory of Krieger and Nelkin and the theory of Kołos gives evidence of inelastic transitions between successive energy levels of the hindered rotation. (auth)

**32369** SOME INVESTIGATIONS OF NEUTRON INELASTIC SCATTERING ON MAGNETICS. Sz. Krańicki, A. Murasik, T. Riste, K. Ruta-Wala, and A. Wanic (Inst. of Nuclear Physics, Krakow). IAEA Preprint No. SM-30/14. 14p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

Diffuse scattering of neutrons connected with the magnetically active reciprocal lattice points was observed in single crystals of franklinite ($Zn_{0.75}Mn_{0.38}Fe_{1.87}O_4$) and chromium oxide ($Cr_2O_3$). In the case of franklinite, the monochromatic beam technique was used. The diffuse scattering at liquid air temperature around $\tau$ = (1 1 1) could be explained as magnon scattering. A quadratic dispersion relation of magnons ($W = \hbar/2m\ \alpha\ q^2$) with $\alpha$ = 50 was obtained. In the case of $Cr_2O_3$ the critical scattering region was investigated around $\tau = (1\ 1\ 0)_{rhomb}$. The white beam technique was used. The data obtained were compared with

those for $Fe_2O_3$ and expressed by means of Van Hove formalism. Considerable differences were observed. (auth)

**32370** NEUTRON-PHONON INTERACTION STUDIES IN COPPER, ZINC, AND MAGNESIUM SINGLE CRYSTALS. E. Maliszewski, J. Sosnowski, K. Blinowski, J. Kozubowski, and I. Padlow (Inst. of Nuclear Research, Warsaw). IAEA Preprint No. SM-30/15. 18p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The phonon dispersion relations in copper single crystals were studied by a triple-axis crystal neutron spectrometer. In the [100] direction the transversal branch was found. This branch fits the data of sound velocity; however, it differs partly from the x ray results of Jacobsen. For the longitudinal branch in the [100] direction, the dispersion curve obtained by Cribier and Jacrot lies well above the Jacobsen's curve, and the experimental points reported support the results of Cribier and Jacrot. The phonon dispersion relations in zinc and magnesium single crystals were studied using the cold neutron method and by a triple-axis crystal neutron spectrometer. The scattering surfaces in the $[\bar{1}010]$ plane of zinc were traced showing the AT and AL branches and phonon dispersion relations in the [001] and [010] directions. The results were compared with those obtained by Johnson. In the [001] direction the present results fit well to Johnson's for the AL branch. In the [010] direction for the AT branch a large discrepancy was found. Some explanation of this discrepancy is given. Similar measurements in the same directions in magnesium single crystals are underway. (auth)

**32371** LATTICE DYNAMICS OF SOME AMMONIUM SALTS BY INVERTED FILTER METHOD. K. Mikke (Inst. for Nuclear Research, Swierk, Poland). IAEA Preprint No. SM-30/16. 22p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

Energy distributions of initially monochromatic neutrons scattered inelastically at 90° for ammonium halides and ammonium nitrate were measured by the inverted filter (beryllium and graphite) method. At room temperatures two sharp peaks were obtained for $NH_4Br$ and $NH_4Cl$ in the range 10–100 Mev. For $NH_4F$ three peaks were observed, and this was confirmed by a separate measurement on the cold neutron facility. For $NH_4I$ and $NH_4NO_3$ only a broad distribution was obtained. The result for $NH_4I$ seems to be consistent with the assumption of a free rotation of an ammonium ion. Measurements at −20, −60, and −150°C were also made. For $NH_4I$ sharp peaks appear at temperatures lower than −20°C. For $NH_4NO_3$ at −60°C the distributions are still like those at room temperature. Temperature variations of intensities for several of the observed peaks were also measured and compared with some theoretical predictions. Additional peaks appear for all halides at lower temperatures, and their nature is being investigated. The results are compared with other data obtained indirectly by other methods, and an attempt to give a qualitative explanation is made. (auth)

**32372** ON THE SCATTERING OF SLOW NEUTRONS BY HYDROGEN AND ETHYLENE. D. Bally, V. Tarina, and S. Todireanu (Inst. of Atomic Physics, Bucharest). IAEA Preprint No. SM-30/17. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The angular distribution of 1.61 Å wavelength neutrons scattered from hydrogen and ethylene was measured. For ethylene the pressure was varied from 15 to 60 atm and for hydrogen from 60 to 110 atm. The investigated angular range was between 5 and 90°. The experimental results were compared with the differential cross sections calculated using the Krieger-Nelkin formula. (auth)

**32373** COLD NEUTRON STUDIES ON HYDROGENOUS LIQUIDS. Karl-Erik Larsson and Ulf Dahlborg (AB Atomenergi, Stockholm). IAEA Preprint No. SM-30/18. 36p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The cold neutron scattering studies of the vibrational and diffusive properties of light and heavy water were continued at the Stockholm reactor. Vibrational frequency spectra were derived from observations on heavy water up to 350°C. The damping of the molecular vibrations and rotations is very strong at the higher temperatures. A study was performed on the quasi-elastic and inelastic scattering from glycerine, a hydrogenous liquid showing a strong variation of its viscosity with temperature. The diffusion constants are several powers of ten larger than those calculated from the Einstein-Stoke or Eyring formulas using the measured viscosity. The variation of line width with temperature shows a tendency opposite of that for water, which indicates that for glycerine, jump diffusion might be the most important process. The broad inelastically scattered spectrum from glycerine shows similarities to the spectra derived from the measurements on light and heavy water. (auth)

**32374** PRACTICAL ANALYSIS OF NEUTRON SCATTERING DATA INTO SELF AND INTERFERENCE TERMS. P. A. Egelstaff (Atomic Energy Research Establishment, Harwell, Berks, Eng.). IAEA Preprint No. SM-30/20. 22p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

Van Hove emphasized the physical significance of the division of neutron scattering data into two parts: the motion of single atoms (self term) and the time dependence of the pair correlation (interference term). Vineyard further emphasized the gaussian component of the self term. Practical methods, involving computing techniques, are discussed for analyzing the two parts. Examples are quoted from the scattering law analysis of beryllium, beryllium oxide, graphite, heavy water, liquid tin, and santowax including the derivation of the generalized frequency function. (auth)

**32375** SCATTERING LAW FOR METAL ATOMS IN CHEMICAL COMPOUNDS. P. A. Egelstaff and G. Holt (Atomic Energy Research Establishment, Harwell, Berks, Eng.). IAEA Preprint No. SM-30/21. 17p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The motions of neutron absorbing atoms in compounds can be studied by measuring the shape of neutron resonance absorption lines. If the independence of nuclear and atomic motions is assumed, the line shape is given by a convolution of a Breit-Wigner function with a scattering law which represents the motions of the atoms. The scattering law is observed with a resolution function equal to the natural width of the resonance. Although this is usually much wider than the experimental resolution of conventional scattering experiments, this method is worthwhile because it has two advantages over the conventional one: there are negligible

interference effects in the observed quantity and the motion of one atom (the species showing the resonance) can be observed in a compound containing many other atoms. Since the scattering law function is non-symmetrical, the measured effect is seen as an asymmetry in line shape. The effect is more significant for oxides than metals since the kinetic energy per atom is greater for the former, leading to a broader scattering law. Measurements of line shapes were made with the DIDO fast chopper and the measured resonance lines are compared between Ta and $Ta_2O_5$; and Hf and $HfO_2$. A calculation of line shape was also made for each case from an assumed frequency function and using the methods of Egelstaff and Schofield with the program LEAP and LINESHAPE. This technique is compared with conventional neutron scattering methods. (auth)

**32376** STUDIES OF PROTON VIBRATIONS IN γ-TITANIUM HYDRIDE. D. H. Saunderson and S. J. Cocking (Atomic Energy Research Establishment, Harwell, Berks, Eng.). IAEA Preprint No. SM-30/23. 11p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The spectra of inelastically scattered neutrons from a sample of titanium hydride (mixed α-titanium and fcc γ-hydride phase) at room temperature were measured by cold neutron scattering and by the beryllium detector method. The profile of the prominent peak at 0.145 ev due to the protons vibrating with respect to the lattice of metal atoms was studied by the beryllium detector method. Scattering of slow incident neutrons provides additional information on the relative intensity and distribution of low frequency modes. With these data the LEAP computer program was used to show that the 0.145 ev peak profile could not result from an Einstein oscillator plus acoustic multiphonon scattering. A generalized frequency distribution, $p(\beta)$, fitting the data was derived and shows that the majority of the normal modes of the proton vibrations are contained in a broad, asymmetric peak about 0.145 ev. (auth)

**32377** COMPARATIVE STUDIES ON SLOW NEUTRON SCATTERING BY SOLID AND LIQUID TIN. Z. Guner and S. J. Cocking (Atomic Energy Research Establishment, Harwell, Berks, Eng.). IAEA Preprint No. SM-30/24. 16p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The scattering of 4.0 and 6.2Å neutrons by tin as solid (210°C) and liquid (240°C) was measured. The scattered spectra at six scatter angles between 20° and 90° was analyzed by time-of-flight methods. At the longer wavelength the low intensity elastic scattered peaks are used to derive the incoherent cross section for tin and the diffusion broadening of the pseudo-elastic peaks in the liquid state are compared with theoretical predictions. Sharp coherent peaks in the solid can be identified and similar but broadened peaks for the liquid are seen. Using the theory of Egelstaff, these peaks can be identified as particular longitudinal phonons. The shape of the liquid spectra suggest that the broadening is mainly due to the random positions of the atoms in the liquid rather than the damping of these phonons. (auth)

**32378** STUDIES OF LIQUID SODIUM BY INELASTIC SCATTERING OF SLOW NEUTRONS. S. J. Cocking (Atomic Energy Research Establishment, Harwell, Berks, Eng.). IAEA Preprint No. SM-30/25. 15p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The scattering of 4.1Å neutrons by liquid sodium at 108, 153, and 198°C was compared with scattering from solid sodium (80°C) at six scatter angles between 20° and 90°. Sodium provides a simple monatomic liquid with coherent and incoherent scattering cross sections of 1.55 and 1.85 barns, respectively. Due to the range of momentum transfers covered it is possible to distinguish and discuss coherent and incoherent effects separately. Three interesting features of the scattered spectra are evident: The near elastic scattering is largely incoherent and shows broadening by diffusive motion less than that expected from a simple (Fick's Law) model. Comparison with estimates from alternative interpretations by Egelstaff and Schofield and by Rahman, Singwi, and Sjölander are presented. The wide spreading spectrum for solid and liquid are similar. At high scatter angles coherent effects appear near the elastic peak and a direct test of Vineyard's convolution approximation is made. (auth)

**32379** THE INELASTIC SCATTERING OF COLD NEUTRONS BY METHANE, AMMONIA AND HYDROGEN. F. J. Webb (Atomic Energy Research Establishment, Harwell, Berks, Eng.). IAEA Preprint No. SM-30/27. 15p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The differential cross sections for the scattering of 4Å neutrons through angles of 20, 30, 45, 75, and 90 were measured for methane, ammonia, and hydrogen at room temperature. Methane and ammonia gave similar results; at the smaller angles the spectrum of scattered neutrons consisted of a quasi-elastic peak of roughly the same wavelength as the incident neutrons, but several times broader, and an inelastic peak at shorter wavelengths. At larger scattering angles the quasi-elastic peak moved to shorter wavelengths, and merged into the inelastic peak, which remained at the same wavelength. These peaks are consistent with scattering from a perfect gas of mass 16 or 17, together with inelastic scattering in which neutrons gain energy at the expense of molecular rotations. The short wavelength edge of the inelastic peak is the same for all scattering angles, as it is determined by the Boltzmann factor (corresponding to room temperature) governing the excitation of the molecular rotations. (At room temperature the excitation of molecular vibrations is negligible). For hydrogen even at small scattering angles the incident spectrum is broadened considerably, as would be expected for scattering from a gas of mass 2, and the peaks due to scattering by molecular rotations and molecular translations overlap. (auth)

**32380** THE PERFORMANCE AND AUTOMATIC OPERATION OF THE LIQUID HYDROGEN COLD NEUTRON SOURCE IN DIDO. F. J. Webb and D. G. Pearce (Atomic Energy Research Establishment, Harwell, Berks, Eng.). IAEA Preprint No. SM-30/28. 16p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

A brief description is given of the design and operation of the liquid hydrogen cold neutron source in the DIDO reactor. Cold neutron gain factors under various conditions were measured, and the performance relative to the BEPO and EL3 sources is discussed. After initial cooling of the refrigerator this source is operated automatically for periods of several days. The problems met in doing this and the techniques employed are described. (auth)

**32381** INELASTIC SCATTERING OF NEUTRONS BY METHYL, ETHYL, AND n-AMYL ALCOHOLS. D. H. Saunderson and V. S. Rainey (Atomic Energy Research Establishment, Harwell, Berks, Eng.). IAEA Preprint No. SM-30/29. 15p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The energy transfer spectra of methyl, ethyl, and n-amyl alcohols at room temperature were measured by cold neutron scattering and beryllium detector methods. A description is given of the apparatus used for the latter measurements. The principle feature observed in each case is a broad band of energy transfers from 0 to 50 mv. There is some indication of the excitation of a level of 170 mv in the neutron energy loss spectra. This corresponds to the molecular vibrational mode in which the hydroxyl group bends with respect to the C-O bond observed by I-R spectroscopy at 170 mv. The C-O bond stretching mode at 128 mv was not observed. The 0–50 mv band is discussed in relation to previous measurements of the variation of total cross section for long wavelength neutrons and optical measurements of free and hindered internal rotations in alcohol molecules. (auth)

**32382** THE MOTION OF HYDROGEN IN WATER. P. A. Egelstaff, B. C. Haywood, and I. M. Thorson (Atomic Energy of Canada Ltd., Chalk River, Ont.). IAEA Preprint No. SM-30/35. 21p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

Recent measurements of neutron scattering by water are combined and analyzed in terms of a generalized frequency function $p(\beta)$ and non-gaussian components. The theoretical calculations are performed with the LEAP program using the methods of Egelstaff and Schofield. Diffusive, rotational, and vibrational components can be seen in the frequency distribution and the change of the first two with temperature observed. The energy of a single molecule rotation is $\simeq$ 0.1 ev at room temperature falling to $\simeq$ 0.07 ev at 150°C. (auth)

**32383** THE NEUTRON SCATTERING LAW AND THE FREQUENCY DISTRIBUTION OF THE NORMAL MODES OF BERYLLIUM OXIDE. R. N. Sinclair (Atomic Energy of Canada Ltd., Chalk River, Ont.). IAEA Preprint No. SM-30/36. 17p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

The scattering of neutrons by phonons in polycrystalline beryllium and beryllium oxide was studied using a phased rotor neutron time-of-flight spectrometer. The differential scattering cross section was measured for incident neutron energies between 0.015 and 0.132 ev at scattering angles from 12 to 150°. The cross sections were expressed in dimensionless energy transfer and momentum transfer units as the scattering law $S(\alpha,\beta)$. The frequency distributions and the functions $p(\beta)$, were deduced from the scattering law after the elimination of interference effects, the effects of multiple phonon scattering, and the Debye-Waller factor. The frequency distribution of beryllium shows a high frequency cut-off corresponding to a Debye temperature of 940°K. The main deviation from a Debye model distribution is a peak at 0.050 ev which corresponds to the transverse optical vibrations. Two peaks occur in the frequency distribution of beryllium oxide corresponding to modes of energy 0.040 and 0.086 ev. These probably correspond to the maximum energies of the acoustical and optical vibrations. (auth)

**32384** A STUDY OF THE PHONON SPECTRUM AND DISPERSION CURVES FOR VANADIUM. M. G. Zemlyanov, Yu. M. Kagan, N. A. Chernoplekov, and A. G. Chicherin (Academy of Sciences, Moscow). IAEA Preprint No. SM-30/50. 26p. (In Russian)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

Measurements of the spectrum of inelastically scattered cold neutrons in a vanadium sample were made with a time-of-flight neutron spectrometer. The phonon spectrum of the vanadium and dispersion curves was established from the experimental data by means of an electronic computer. (auth)

**32385** A STUDY OF COLD NEUTRON INELASTIC SCATTERING ON CERTAIN HYDROGENOUS SUBSTANCES. M. G. Zemlyanov and N. A. Chernoplekov (Academy of Sciences, Moscow). IAEA Preprint No. SM-30/51. 17p. (In Russian)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

Working with a beryllium filter for separating the spectral line of cold neutrons and using the time-of-flight method, the spectrum of inelastically scattered cold neutrons in benzene, diphenyl, and in irradiated and non-irradiated polyethylene was studied. The results are compared with the results of optical measurements. (auth)

**32386** THEORY OF THE INFLUENCE OF PHONON-PHONON AND ELECTRON-PHONON INTERACTIONS ON THE SCATTERING OF NEUTRONS BY CRYSTALS. J. J. J. Kokkedee (Univ. of Utrecht). IAEA Preprint No. SM-30/59. 36p. (In English)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

As predicted by harmonic theory the coherent inelastic spectrum of neutrons, scattered by a single, non-conducting crystal, for a particular angle of scattering consists of a number of delta-function peaks superposed on a continuous background. The peaks correspond to processes in which one phonon is absorbed or emitted by the neutron; the background arises from multi-phonon processes. When anharmonic forces (phonon-phonon interactions) are present, the delta-function peaks are broadened into finite peaks, while their central frequencies are shifted with respect to the harmonic values. In the case of a metal there is in addition to phonon-phonon interactions an interaction between phonons and conduction electrons, which also gives a contribution to the displacement and broadening of the one-phonon peaks. The shifts and widths of the scattering peaks are studied by the many particle perturbation theory, making extensive use of diagram techniques. It is assumed that independent of the strength of the interactions, the width of each peak is small compared to the value of the frequency at its center; only then the peaks can be considered as being well defined with respect to the background to higher order in the interactions. This condition is expected to be fulfilled for temperatures below the melting point and a small phonon wave vector. Approximate calculations are performed to give some insight into the magnitude of the effects. (auth)

**32387** PHONON SCATTERING SPECTRA OF NICKEL. N. A. Chernoplekov, M. G. Zemlyanov, A. G. Chicherin, and B. G. Lyashchenko (Kurchatova Inst. of Atomic Energy,

Academy of Sciences, USSR). IAEA Preprint No. SM-30/63. 12p. (In Russian)

To be published in Proceedings of the IAEA Symposium on Inelastic Scattering of Neutrons in Solids and Liquids, Chalk River, Canada, 10-14 September 1962.

Information is given for measuring inelastic neutron scattering in nickel-62 with zero mean coherent scattering amplitudes, and results are given of phonon spectra reduction based on these measurements. (R.V.J.)

## Nuclear Properties and Reactions

*Refer also to abstract 32172.*

**32388** (BNL-1652) YIELD OF $Kr^{85}$ AND $Xe^{133}$ IN THE THERMAL NEUTRON FISSION OF $U^{235}$ AND YIELD OF $Kr^{85}$ IN THE THERMAL NEUTRON FISSION OF $Pu^{239}$. Seymour Katcoff and William Rubinson (Brookhaven National Lab., Upton, N. Y.). [1953]. Contract [AT(30-2)-GEN-16]. 87p.

Absolute radiochemical measurements of the yields of $Kr^{85}$ and $Xe^{133}$ in the thermal neutron fission of $U^{235}$ and $Kr^{85}$ in the thermal neutron fission of $Pu^{239}$ are reported. Accuracy estimates are based on a detailed investigation of the possible sources of error in the fission counting, chemical procedure, and beta-counting (gas-phase proportional counter). Other accurate works on fission yield measurements are summarized, and some 27 fission yields are listed. Some by-products are also reported: the independent yields of $Xe^{133}$ and $Xe^{135}$ in $U^{235}$ fission, and a remeasurement of the half life of $I^{133}$. (P.C.H.)

**32389** (BNL-6271) AN INVESTIGATION OF THE REACTION $O^{16}(\alpha,2\alpha)C^{12}(g.s.)$. P. F. Donovan, J. V. Kane (Bell Telephone Labs., Inc., Murray Hill, N. J. and Brookhaven National Lab., Upton, N. Y.); C. P. Baker, J. F. Mollenauer, and C. Zupancic (Brookhaven National Lab., Upton, N. Y.). [nd]. Contract [AT(30-2)-Gen-16]. 8p.

An investigation was made of the angular and energy correlations between two $\alpha$ particles emitted when $O^{16}$ was bombarded with 40-Mev alpha particles. It was found that the low lying states in $O^{16}$ are preferentially excited. The rapid intensity variation at high energies indicated that high spin states contribute appreciably to the total yield. "Giant" peaks in the angle-energy correlation occurred at angle and energy regions where the recoil momentum of the $C^{12}$ nucleus was small. (M.C.G.)

**32390** (CEA-2177) THÉORIE DES SPECTRES DES NOYAUX À COUCHES COMPLÈTES (THESES). (Spectra Theory for Nuclei with Closed Shells (thesis)). Vincent Gillet (France. Commissariat à l'Énergie Atomique. Centre d'Études Nucléaires, Saclay). 1962. 207p.

A unified theory for the spectra of nuclei with closed shells, based on the elementary particle-hole excitation of these systems, is applied to a study of $C^{12}$, $O^{16}$, and $Ca^{40}$. Two approximations are made. The first consists in diagonalizing the residual two-body interaction in a limited subspace having one particle and one hole configurations. Its validity depends on the high energy necessary for exciting a particle-hole pair. The second approximation consists in resumming the infinite sub-series of the particle-hole diagrams. It is equivalent to the Hartree-Fock method depending on the time, or to Quasi-Boson method. Its domain of validity in the nuclear case is not thoroughly understood. The summed diagrams are preponderant at the high density limit, when the nuclear density is about unity. The violation of the Pauli principle in this approximation is only justified if the number of excited pairs is small with respect to the number of particle states available; in the case of light nuclei the degeneracies of the shells are small. Nevertheless this approximation, which postulates the existence of an average nuclear field, varying slowly with time with respect to the nucleons' periods has the merit of being self-consistent, of giving orthogonal proper states in the non-physical state of the mass center, and of improving the calculation of the summation rules. In order to determine and to limit the role of phenomenology in the results obtained using these approximations, a maximum amount of experimental data is calculated. By applying method of least squares to 14 energy levels of $O_2$ and C, the region of optimum agreement in the effective interaction parameters is determined. This region is in part a function of the numerical approximations made. It is compatible with certain characteristics of free nucleon-nucleon scattering. The research results favors the second approximation which alone leads to a region of optimum agreement identical for both C and $O_2$. An excellent general agreement is obtained with the known spectra of these two nuclei. The importance of higher order terms in the calculation of the $3^-$ and $5^-$ collective states for $Ca^{40}$ is demonstrated; furthermore it is possible to explain these levels only by the second approximation. Certain forecasts are made using the effective forces thus found. (auth)

**32391** (GA-3083) RANGE OF RECOIL ATOMS. V. A. J. van Lint and M. E. Wyatt, Jr. (General Atomic Div. General Dynamics Corp., San Diego, Calif.) Apr. 20, 1962. Includes Appendices. Contract AF 33(616)-6795. 231p. (ARL-62-389)

The range-energy relation for atoms with energies between 5 and 500 kev moving in solids was studied experimentally and theoretically. Recoil atoms were produced in photonuclear reactions receiving momentum primarily from the emitted particle (neutron, proton or alpha). The average energy of the recoil atom was evaluated from the energy dependence of the photon absorption cross section and the known energy spectrum of the emitted particles. The range was calculated by measuring the fraction of the recoil atoms escaping from a target foil and stopped by a nearby Al catcher foil. The photonuclear reactions resulted in radioactive recoil atoms capable of being detected by standard radiochemical techniques. Theoretical calculations were performed to evaluate various interatomic potential energy functions, to solve the classical scattering relations in an exponentially-screened Coulomb potential, and to perform a Monte Carlo calculation of range-energy relations in a random lattice with an exponentially-screened Coulomb scattering potential. These calculations indicate that at the impact parameters which are significant for the range-energy problem, the screening radius in an exponentially-screened Coulomb potential should be approximately twice the characteristic length of a Fermi-Thomas atom. This same adjustment produces agreement between theoretical range-energy relations and the experimental data. (auth)

**32392** (GEAP-4008) THE HALF-LIFE AND GAMMA-RAY ABUNDANCE OF Cs-137. B. F. Rider, J. P. Peterson, Jr., and C. P. Ruiz (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). June 1, 1962. Contract [AT(04-3)-189]. 46p.

The half life of cesium-137 was determined to be 29.2 ± 0.3 years by an all mass spectrometric method. The abundance of the 662 Kev gamma-ray in the decay scheme was found to be 0.82 ± 0.03 per beta disintegration. In the course of the work, the isotopic distribution of natural barium was determined with improved accuracy to be (72.11 ± 0.06)% 138, (11.18 ± 0.05)% 137, (7.77 ± 0.02)% 136,

(6.42 ± 0.03)% 135, (2.33 ± 0.02)% 134, (0.091 ± 0.003)% 132, and (0.098 ± 0.002)% 130. (auth)

**32393** (LADC-5267) SOME RECENT DEVELOPMENTS IN FISSION PHYSICS. R. B. Leachman (Los Alamos Scientific Lab., N. Mex.). [1962]. Contract [W-7405-eng-36]. 36p.

It is noted that although fission is the starting point of essentially all aspects of the present nuclear industry, very limited basic understanding of the process exists. If an all-encompassing model of fission were devised, it appears doubtful that full understanding of fission would immediately result. The six fission characteristics which should be accommodated by a fission model are examined and a model is presented which incorporates these characteristics. Other discussion is presented concerning angular momentum effects in fission and neutron emission from fission. (J.R.D.)

**32394** (LADC-5367) THE TIME REQUIRED FOR NUCLEAR FISSION (thesis). William E. Stein (Los Alamos Scientific Lab., N. Mex.). 1962. Contract [W-7405-eng-36]. 136p.

The mean lifetime of compound nuclei formed in the fast-neutron-induced-fission process is measured. The measuring method is based on the recoil of the compound nucleus following neutron capture and the secondary electrons emitted by fission fragments. The importance of the higher energy electrons, the so-called delta rays, formed in the primary ionization process is considered. The subsequent secondary ionization produced by these delta rays provides a natural explanation of a previous experimental fact that the number of electrons emitted by a fission fragment is larger when the fragment emerges than when it enters the same surface. This viewpoint is extended to a consideration of the dependence of the electron yield on the depth beneath the surface at which a fission event takes place. On the basis of a qualitative theory, this yield is expected to increase with depth and approach asymptotically a limiting value which corresponds to the case where the fragment emerges from depths larger than the maximum range of the delta rays. Measurements of this dependence of the yield on the depth were performed with layers of uranium tetrafluoride. These results were used to measure the average distance traversed by the recoiling compound nuclei during the time interval between neutron capture and fission. From a comparison of these results and the previously determined dependence of the yield on depth, an estimate of the average recoil distance and, therefore, a measure of the mean lifetime could be obtained. The mean lifetimes of the compound nuclei of U-239 and Np-238 were, within the sensitivity of the present method, consistent with zero. Upper limits of the lifetimes are considerably lower than those previously obtained. The total mean lifetimes for target nuclei of U-238 and Np-237 were found to be $\tau(\text{U-238}) < 6 \times 10^{-14}$ and $\tau(\text{Np-237}) < 4 \times 10^{-14}$ sec. The partial mean lifetimes for fission and neutron emission were determined from the relation $\Gamma = \Gamma_f + \Gamma_n$ and the ratio of the fission and neutron emission widths. The partial mean lifetimes are as follows: $\tau_f(\text{U-238}) < 4 \times 10^{-13}$; $\tau_n(\text{U-238}) < 7 \times 10^{-14}$; $\tau_f(\text{Np-237}) < 9 \times 10^{-14}$; and $\tau_n(\text{Np-237}) < 7 \times 10^{-14}$ sec. (auth)

**32395** (LADC-5388) INVESTIGATION OF THE ENERGY LEVELS OF $He^6$ (thesis). Roy Al Olson (Los Alamos Scientific Lab., N. Mex.). 1962. Contract [W-7405-eng-36]. 47p.

At Los Alamos, one of the Van de Graaff accelerators is used to accelerate tritons up to 2.5 Mev in energy. Using this machine and bombarding a Li target, the $Li^7(T,\alpha)He^6$ reaction can be studied. The energy of the $\alpha$-particles from this reaction can be used in determining the energy levels of $He^6$. A broad-range spectrograph employing a 30-in. nuclear-track plate was constructed and employed in conjunction with the Van de Graaff. The construction and operation of the spectrograph are described. Preliminary results from scanning the exposed nuclear plates give evidence for the ground state and the first excited state of $He^6$ with the energy of the first excited state being 1.772 ± 0.017 Mev. (auth)

**32396** (NP-11745) CALCULO DE SECCIONES EFICACES X(n,p)Y CON NEUTRONES DE ENERGIAS ENTRE 2–5 Mev. (Calculation of the Effective Cross Sections of the Reaction X(n,p)Y with Neutrons in the Energy Range 2–5 Mev). J. Rapaport and A. Trier (Chile. Universidad, Santiago. Instituto de Fisica y Matematicas). May 1960. 12p.

Parallel with experimental work to measure the $Co^{58}(n,p)Ni^{58}$ effective cross sections with monoenergetic neutrons between 2 and 3.6 Mev, it was necessary to estimate the theoretical behavior of these cross sections. The statistical theory of Blatt and Weisskopf was used in the calculation. The theoretical results obtained for square-well and diffuse-well development are compared with the experimental results. (J.S.R.)

**32397** (NP-12012) NUCLEAR DOUBLE RESONANCE IN THE ROTATING FRAME. S. R. Hartmann and E. L. Hahn (California. Univ., Berkeley). [196?]; 44p.

A double nuclear resonance spectroscopy method is introduced which depends upon effects of magnetic dipole-dipole coupling between two different nuclear species. In solids a minimum detectability of the order of $10^{14}$ to $10^{16}$ nuclear Bohr magnetons/$cm^3$ of a rare b nuclear species is predicted, to be measured in terms of the change in a strong signal displayed by an abundant a nuclear species. The a magnetization is first oriented in the frame of reference rotating at its Larmor frequency. The b nuclear resonance is obtained simultaneously with a second radio-frequency field; and with the condition that the a and b spins have the same Larmor frequencies in their respective rotating frames, a cross-relaxation will occur between the two spin systems. The cross-relaxation interaction, which lasts for the order of a long spin-lattice relaxation time of the a magnetization, is arranged to produce a cumulative demagnetization of the a system when maximum sensitivity is desired. Final observation of the reduced a magnetization indicates the nuclear resonance of the b system. The concepts of uniform spin temperature, when it is valid, and of non-uniform spin temperature where spin diffusion is important, are applied. The density matrix method formulates the double resonance interaction rate in second order. Preliminary tests of the double resonance effect are carried out with a nuclear quadrupole system. (auth)

**32398** (NYO-9287) MEASUREMENT OF THE RATE OF THE REACTION $\mu^- + C^{12} \rightarrow B^{12} + \nu$ (thesis). Eugene J. R. Maier (Carnegie Inst. of Tech., Pittsburgh). May 1962. Contract AT(30-1)-882. 99p.

The rate of the reaction $\mu^- + C^{12} \rightarrow B^{12} + \nu$ was measured by stopping negative muons from the Carnegie Tech synchrocyclotron in a plastic (CH) target. The number of incident muons was monitored by observing the amplitude of their characteristic exponential decay, and the reaction product, $B^{12}$, was detected by observation of its beta decay with characteristic meanlife 29.3 msec. Separation of the partial capture rate to the ground state of $B^{12}$ from the total capture rate was effected by direct observation of the emitted gamma ray in coincidence with the recoil of the

$B^{11}$ ion from the neutrino emission. The result, for capture to the ground state, is $\lambda_B^{gnd} = (6.75^{+0.30}_{-0.75}) \times 10^3$ sec$^{-1}$ which is in agreement with several theoretical calculations. (auth)

**32399** (TID-16652) THE ($\alpha$,d) REACTION ON TITANIUM. J. L. Yntema and W. J. O'Neill (Argonne National Lab., Ill.). June 1962. Contract [W-31-109-eng-38]. 6p.

A survey of the ($\alpha$,d) reaction at 43 Mev on a number of nuclei in the region around A = 60 was made. Data indicate that the probability for the occurrence of the ($\alpha$,d) reaction is not affected by the respective shell-model orbits of the proton and neutron. No general correlation was found in the location of the gross-structure peaks from ($\alpha$,d) and ($\alpha$,t) reactions leading to the final nucleus. (J.R.D.)

**32400** (TID-16665) COLLECTIVE LEVELS IN $Ni^{58,60,62}$ AND $Zn^{64,66,68}$. Howard W. Broek (Argonne National Lab., Ill.). June 1962. Contract W-31-109-eng-38. 6p. (UAC-6576)

Even isotopes of Ni and Zn were studied by alpha scattering. The strength of the $3^-$ group is about three times as great in Zn as in Ni, but that of the $2^+$ group is about the same in both elements. The strength of collective groups increases with increasing A in Ni but decreases with increasing A in Zn. (auth)

**32401** (UCRL-5239) $Li^6$ AND $Li^7$(n,2n) CROSS SECTIONS AT 14.1 Mev. V. J. Ashby, H. C. Catron, L. L. Newkirk, C. J. Taylor, and M. A. Williamson (California. Univ., Livermore. Lawrence Radiation Lab.). May 29, 1958. Contract W-7405-eng-48. 5p.

An absolute measurement of the 14.1-Mev (n,2n) cross sections of $Li^6$ and $Li^7$ was made using the large scintillator technique, resulting in cross sections in barns of 0.070 ± 0.006 and 0.056 ± 0.005 for $Li^6$ and $Li^7$, respectively. (auth)

**32402** (UCRL-9524) DECAY-ENERGY SYSTEMATICS OF THE HEAVY ELEMENTS. Isadore Perlman and Frank Asaro (California. Univ., Berkeley. Lawrence Radiation Lab.). Jan. 17, 1961. Contract W-7405-eng-48. 30p.

Total decay energies for the four radioactive series are summarized. The conditions and regions of alpha instability are shown in graphic form. All alpha particle energies and abundances in the heavy-element region were compiled. Decay schemes for three typical even-even alpha emitters are shown. Energy spaces between the ground state and first excited state of even-even nuclei are summarized as a function of neutron number and proton number. It was found to be possible to correlate alpha decay lifetimes empirically and to arrive at systems which can be used to predict half lives. (M.C.G.)

**32403** (UCRL-10342) MASS-ENERGY RELATIONS IN THE FISSION OF HIGHLY EXCITED HEAVY NUCLEI (thesis). Eldon Lee Haines (California. Univ., Berkeley. Lawrence Radiation Lab.). June 29, 1962. Contract W-7405-eng-48. 82p.

Mass-energy relations in the fission of the compound nucleus $Fm^{254}$ were studied at excitation energies in the range from 58 to 116 Mev. This compound nucleus was produced by bombardments of $Th^{232}$, $U^{238}$, and $Pu^{242}$ with the heavy ions $Ne^{22}$, $O^{16}$, and $C^{12}$, respectively. The kinetic energies of the two fission fragments from each event were measured using semiconductor detectors. From these energies the masses and total kinetic energies were calculated. The kinetic-energy distributions as a function of mass asymmetry, and the mass distributions as a function of the kinetic energy were studied. It was found that the average kinetic energies were consistent with those expected from electrostatic repulsion of the two fragments at a nearly constant separation. The bell-shaped mass distributions narrowed rapidly as the kinetic energies of the fragments increased. The quantitative behavior of this narrowing suggests that most of the initial excitation energy of the compound nucleus is not available either for conversion into kinetic energy of the fragments or for the production of asymmetric mass divisions that are energetically unfavorable. (auth)

**32404** (UCRL-10362) PREFERENTIAL POLAR ALPHA-PARTICLE EMISSION IN ORIENTED CALIFORNIUM AND EINSTEINIUM (thesis). Quirino Oli Navarro (California. Univ., Berkeley. Lawrence Radiation Lab.). July 12, 1962. Contract W-7405-eng-48. 92p.

Nuclear alignment experiments were performed on $Es^{253}$ and $Cf^{249}$, incorporated as the tripositive ions, in single crystals $Nd(C_2H_5SO_4)_3 \cdot 9H_2O$. The actinides and lanthanides were shown to be isomorphous in this salt. The low temperatures needed were attained by adiabatic demagnetization of the samples. Alpha particles emitted from the samples and detected with Ge surface-barrier detectors were found to be highly anisotropic; in the case of Es the nuclear orientation was saturated at a relatively high temperature. The alpha particles from these nuclei were shown to be preferentially emitted from the "tips," thus providing two independent confirmations of the prediction of Hill and Wheeler. The S- and D-waves in the "favored" transitions in these isotopes were found to be in phase. The L = 2,4 waves in Es were interpreted as being out of phase; the L = 3,5 components in Cf could not be determined with certainty, although an out-of-phase relationship was indicated. By use of the theory of Elliott and Stevens, the electronic ground state resulting from the crystal-field splitting of the ground level of tripositive Es in $Nd(C_2H_5SO_4)_3 \cdot 9H_2O$ was calculated. It was found that the theory, developed for the lanthanides, can be applied to the actinides as well. Values of $\langle r^{-3} \rangle$ for the 5f electrons were estimated; these values and the above theory were used in deriving values of the nuclear moments. From assumed nuclear spins I = 1/2 and I = 9/2 for $Es^{253}$ and $Cf^{249}$, respectively, nuclear moments of $|\mu_{253}| = 4.9$ n.m. and $|\mu_{249}| = 1.3$ n.m. were derived. Errors of about 20%, of which one-half comes from uncertainties in the theory, should be attached to these values. The gamma rays of $Cm^{245}$, following the alpha decay of $Cf^{249}$, were found to be anisotropic. Appreciable attenuation of the gamma-rays was found, indicating some reorientation of the nuclear spin of the daughter nucleus. Nuclear-alignment experiments were also performed on $Dy^{155}$ and $Dy^{157}$. The angular distributions of the gamma rays following the decays of both isotopes were found to be anisotropic. Spin 5/2− was assigned to the states at 227 kev in $Tb^{155}$ and at 327 kev in $Tb^{157}$. The nuclear moments $|\mu_{155}| = 0.21 \pm 0.05$ n.m. and $|\mu_{157}| = 0.32 \pm 0.02$ n.m. were derived, based on I = 3/2 for both isotopes as well as pure L = 1 beta decay to the 5/2− states. The practicality of Ge surface-barrier detectors was again demonstrated. It was found that these are suitable for use at low temperatures for detecting alpha and beta particles. Experiments indicated that under the conditions demanded in this line of investigation, these detectors are superior to other means of detection of charged particles. (auth)

**32405** (WAPD-TM-324) ANALYSIS OF THE NEUTRON CAPTURE CROSS SECTION AND RESONANCE INTEGRAL OF HAFNIUM. I. Itkin (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Aug. 1962. Contract AT(11-1)-Gen-14. 19p.

For Hf the Breit-Wigner noninterference resonance theory of neutron cross sections does not correlate the experimentally measured values of the resonance integral

and its 2200 m/s capture section. This theory, previously verified for many nuclides, is applied to the naturally occurring isotopes of Hf, and comparisons are made with the results obtained from observed data. The apparent lack of consistency among the experimental and calculated results is reviewed, and a critical analysis is made of the significant differences. It is concluded that natural Hf has a resonance integral of $2000^{+200}_{-300}$ barns and a 2200 m/s capture cross section of 105 ± 5 barns. (auth)

**32406** (NP-tr-916) HYPERFINE STRUCTURE AND THE ATOMIC NUCLEUS. H. Kallmann and H. Schueler. Translated by L. F. Secretan (U.K.A.E.A. Atomic Energy Research Establishment, Harwell, Berks, Eng.) from Ergeb. exakt. Naturw., 11: 134-75(1932). 70p.

Experimental methods for determining hyperfine structure are described. The magnetic hyperfine-structure splitting of spectra is discussed in terms of the elementary theory of the interaction of two magnetic moments, the intensity laws, and the quantitative theory of coupling between nucleus and electron shell. Hyperfine structures were determined from the interval rule and intensity law. A comparison was made between experiment and quantitative coupling theory. Problems of the structure of the nucleus and the isotope shift are discussed. (M.C.G.)

**32407** A SIMPLE THEORY OF THE PHOTODISINTEGRATION OF $^9$Be AT LOW ENERGIES. A. Kowalska (Jagellonian Univ., Krakow). Acta Phys. Polon., 21: 583-96(1962). (In English)

The cross section for the photodisintegration process of $Be^9$ in the energy range 1.667–5 Mev was calculated on the basis of the molecular model of $Be^9$. The parameters were chosen so as to obtain the best adjustment to the experimental curve of M. J. Jakobson. The three peaks of this curve result from electric dipole transitions from the ground state of $Be^9$ to: $S_{\frac{1}{2}}$ neutron state with $Be^8$ left in its ground state (peak at 1.7 Mev) $D_{\frac{3}{2}}$ neutron state with $Be^8$ left in its ground state (peak at 2.9 Mev) $S_{\frac{1}{2}}$ neutron state with $Be^8$ left in the excited state of 2.9 Mev (peak at 4.6 Mev). The experimental results of J. H. Carver, E. Kondaiah, and B. D. McDaniel were also partly explained. (auth)

**32408** SIMPLE DERIVATION OF THE ELECTRON-NUCLEUS CONTACT HYPERFINE INTERACTION. George T. Rado (Naval Research Lab., Washington, D. C.). Am. J. Phys., 30: 716-18(Oct. 1962).

A derivation is given of the Fermi formula for the contact hyperfine interaction energy between the magnetic moment of a nucleus and that of the surrounding electrons. It is shown that the contact hyperfine field at the nucleus is necessarily equal to the magnetic induction in the interior of a sphere possessing a uniform electronic magnetization. Simplifications achieved in the derivation do not seem to result in a loss of rigor, and they do not require the introduction of essentially unfamiliar assumptions. (auth)

**32409** ANGULAR DISTRIBUTION OF NEUTRONS FROM THE REACTION $Be^9(\alpha,n)C^{12}$ NEAR 20 Mev. G. Deconninck, G. Demortier, M. de Vroey, J. P. Meulders, and J. Simonet (Universitè, Louvain, Belgium). Ann. soc. sci. Bruxelles. Ser. I, 69-80(1962). (In French)

Various mechanisms for the $Be^9(\alpha,n)C^{12}$ reaction at $\alpha$ energies of 16 to 23 Mev are analyzed, including $Be^9$-stripping, $\alpha$-stripping, compound-nucleus-formation, and knock-on mechanisms. On the basis of the angular distributions of the neutrons leading to the first excited state of $C^{12}$, it is concluded that the knock-on process is the most probable mechanism for the reaction. (T.F.H.)

**32410** SCATTERING OF ALPHA-PARTICLES BY A VIBRATIONAL NUCLEUS. L. J. Tassie (Argonne National Lab., Ill. and Australian National Univ., Canberra). Australian J. Phys., 15: 135-42(June 1962).

The elastic and inelastic scattering of $\alpha$-particles by a vibrational nucleus is calculated using plane-wave Born approximation. The excitation of both single-phonon and two-phonon states is considered. The effect of the diffuseness of the nuclear surface is included. The result for elastic scattering and the excitation of the single-phonon $2^+$ and $3^-$ states is in good agreement with experiment for $Ni^{58}$. The approximations used are discussed, and it is suggested that excitation of $0^+$, $1^-$, and $5^-$ states should provide the best experimental test of the theory of two-phonon excitation of nuclei. The energies of the vibrational states are also considered. (auth)

**32411** ON THE DECAY OF $Rh^{104m}$. M. Mandelli Bettoni (CESNEF. Milan). Energia nucleare (Milan), 9: 385-7(July 1962). (In English)

Coincidence measurements of the $\gamma$ rays emitted in the decay of $Rh^{104m}$ put into evidence the existence of a 96 kev level. The proposed decay scheme permits one to interpret some previous results on the neutron capture $\gamma$ rays. The conversion coefficient of the 77 kev transition is $\alpha_{k,\pi} = 22 \pm 1.8$. The spins of the levels appear to be 1+, 2−, 2+ (or 2−), 5+. (auth)

**32412** STUDY OF THE POSITRON SPECTRA EMITTED BY DECAY OF $Bi^{205}$ AND $Bi^{206}$. C. F. Perdrisat, J. H. Brunner, and H. J. Leisi (E.P.F., Zurich). Helv. Phys. Acta, 35: 175-210(1962). (In French)

A study of the positron spectra emitted in the decay of $Bi^{205}$ and $Bi^{206}$ leads to the observation of monoenergetic K-positrons of two transitions following electron capture disintegrations. For the 1720-kev transition that depopulates the 3404-kev level in $Pb^{206}$, the number of K-positrons emitted per gamma is found to be: $(7.2 \pm 2.1) \times 10^{-6}$ (r.m.s. error). From this result the total mean life of the initial level is computed with the help of a value for the coefficient of monoenergetic positron formation. This leads to $\tau = 0.92 \times 10^{-14}$ sec. For the 1863-kev transition in $Pb^{205}$, the number of K-positrons emitted per gamma is found to be: $(2.7 \pm 1.1) \times 10^{-6}$ (r.m.s. error). If a particular decay scheme is assumed, this value leads to a total mean life for the 2566-kev level in $Pb^{205}$ of $\tau = 1.8 \times 10^{-16}$ sec. Three transitions with energy 1845, 1880, and 1903 kev are detected from their conversion lines and the internal pair spectra; all three belong to the $Bi^{206}$ decay. The first two are identified as E1 transitions, and the third can be an E2 or M1. The upper limit for the K-positron branching ratio is $9 \times 10^{-6}$ and $2.8 \times 10^{-6}$ positron per gamma for the 1845- and 1880-kev transitions respectively. The $\beta^+$ continuum belonging to $Bi^{205}$ has a maximum energy of (990 ± 10) kev and a log ft-value of 9.35 ± 0.3. A $\beta^+$ continuum that depopulates the $Bi^{206}$ ground state is found; the maximum energy is (977 ± 33) kev and log ft is 11.0 ± 0.3. The decay schemes of both isotopes are discussed in view of these results. (auth)

**32413** THE SHAPE OF THE DOPPLER-BROADENED NUCLEAR RESONANCE FLUORESCENCE LINE. B. I. Deutch (Bartol Research Foundation, Philadelphia). J. Franklin Inst., 273: 227-32(Sept. 1962).

Resonance fluorescence from the 279 kev level of $Tl^{203}$ was studied using a high speed rotor. The shape of the complete Doppler-broadened resonance fluorescence line was measured by observing resonance scattering at different source velocities. The source velocities were varied

from a minimal effect at rest through the maximum resonance effect at 460 m/s until the effect dropped almost to zero again at 930 m/s. It is shown that the ratio of the lifetime of the 279 kev transition calculated from the data in the lower half of the curve to that calculated from the upper part of the curve is 1.02 ± 0.04. Also, the ratio of the lifetimes computed from the data (using the resonance cross-section formula) to the lifetime calculated from the area under the curve (which is proportional to the integral over the velocity of the resonance cross section) is 1.01 ± 0.04. As expected, the use of the area under the Doppler-broadened line in the calculation allows nuclear lifetime measurements independent of possible line structure. (auth)

**32414** THE FISSION PRODUCTS $^{81}$Se AND $^{83}$Se. I. F. Croall and H. H. Willis (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Inorg. & Nuclear Chem., 24: 221-7(Mar. 1962). (In English)

The cumulative yields of the isomers of $Se^{81}$ and $Se^{83}$ were measured in the thermal neutron fission of $U^{233}$ and $U^{235}$ and in the 20 Mev proton fission of $U^{235}$. It is shown that for both the isomer pairs the independent yield of the high spin isomer is greater than that of the low spin isomer in 20 Mev proton fission of $U^{235}$. (auth)

**32415** PROOF OF A CONJECTURE BY DYSON IN THE STATISTICAL THEORY OF ENERGY LEVELS. J. Gunson (Univ. of Birmingham, Eng.). J. Math. Phys., 3: 752-3 (July-Aug. 1962).

A conjectured identity relating the statistical properties of two types of ensembles occurring in a statistical theory of the distribution of energy levels in nuclei and other complex systems is proved. (auth)

**32416** TWO-QUASI-PARTICLE STATES IN EVEN-MASS NUCLEI WITH DEFORMED EQUILIBRIUM SHAPE. C. J. Gallagher, Jr., and V. G. Soloviev. Kgl. Danske Videnskab. Selskab, Mat.-fys. Skrifter, 2: No. 2, 1-68 (1962). (In English)

The energy levels in even-even nuclei and the beta transition rates between even-even and odd-odd nuclei in the 150 < A < 190 region are analyzed. The excitations in these nuclei are describable as rotational states based upon intrinsic states. With the exception of systematically occurring excited 2+ states in even-even nuclei, it is shown that the intrinsic states are describable as two-particle excitations, if Nilsson wave functions are used to characterize the single-particle states. The level energies and beta transition rates are compared with theoretical values that take into account the effect of pairing correlations. The pairing correlations are evaluated with inclusion of "blocking." (auth)

**32417** SHELL MODEL CALCULATIONS OF ALPHA DECAY RATES OF EVEN-EVEN SPHEROIDAL NUCLEI. H. J. Mang and J. O. Rasmussen. Kgl. Danske Videnskab. Selskab, Mat.-fys. Skrifter, 2: No. 3, 1-39(1962). (In English)

The formulation of the alpha decay rate theory based on the independent-particle shell model wave functions is extended to apply to spheroidally deformed nuclei. This method essentially projects out of the shell model wave function of the most lightly bound neutrons and protons a finite-sized gaussian, singlet-spin alpha-particle internal wave function, resulting in a wave function in the center-of-mass coordinate of the alpha cluster. This wave function serves to fix the boundary condition on the nuclear surface for the irregular type Coulomb wave solution through the anisotropic barrier. The independent-particle formulation is generalized to include correlation effects arising from the pairing interaction. Numerical calculations of relative alpha intensities to rotational states of several even nuclei of elements 92 to 100 are carried out using numerical wave functions. The theoretical results nicely show the essential features of the relative intensity patterns, although the theoretical intensity of the decay to the first excited 2+ state is too high. The absolute transition probability calculated for $Cm^{242}$ is about a factor of 60 too low assuming a particular optical model potential for the barrier, but the factor is extremely sensitive to this latter assumption. The essential role of the configuration mixing induced by the pairing force in smoothing the decay rate changes from nucleus to nucleus, and in giving a large enhancement of the absolute rate, is pointed out in the discussion. (auth)

**32418** $Ag^{108}$ GAMMA EMISSION. A. Bakhmat, V. Belogurov, and L. Pelekis (Inst. of Physics, Academy of Sciences, Latviyskaya SSR). Latvijas PSR Zinatnu Akad. Vestis, No. 2(175), 79-82(1962).

The gamma spectrum of various old Ag sources was determined in the range of 0–1100 kev with a double coincidence scintillation spectrometer. NaI(Tl) crystals (20 × 30 mm) with a photo multiplier were used as detector. The resolving power of the analyzing and the controlling spectrometers was 9 and 10.5%, respectively, for the 661-kev line of $Cs^{137}$. Further, the spectra of the $\gamma$-$\gamma$ coincidences and of the sum-coincidences were determined. The existence of a long-lived $Ag^{108m}$ isomer was proved, in the spectrum of which lines with energies of 80, 430, 620, and 725 kev were observed. Coincidences of the 430-kev quanta with 620- and 725-kev quanta, of the 620-kev quanta with 430- and 725-kev quanta, and of the 725-kev quanta with 430- and 620-kev quanta were ascertained. 80-kev quanta did not coincide with quanta of the three other lines. (OTS)

**32419** HALF-LIFE OF RADIOCARBON. H. Godwin (Cambridge Univ., Eng.). Nature, 195: 984(Sept. 8, 1962).

A resolution was adopted on the half life of $C^{14}$ by the Fifth Radiocarbon Dating Conference. The resolution confirms the value of 5,730 ± 40 yr as the best value available, but recommends that radiocarbon age results continue to be reported on the basis of the Libby half life 5,568 yr, in order to allow time for the development of a more reliable value. Published dates may be converted to the basis of the new half life by multiplying by 1.03. (D.L.C.)

**32420** NUCLEAR ALIGNMENT PRODUCED BY ($\alpha$,$\alpha'$) PROCESSES IN EVEN NUCLEI. Ole Hansen and Ove Nathan (Univ. of Copenhagen). Nuclear Phys., 37: 177-93(Aug. 1962). (In English)

Angular distributions of $\gamma$ rays following inelastic scattering of 14- to 20-Mev $\alpha$ particles by medium-weight even nuclei are measured. The $\gamma$ rays are observed in coincidence with backscattered projectiles, detected by a ring-shaped $\alpha$ counter, symmetric with respect to the beam direction. Excitation–de-excitation spin sequences of 0–2–0 and 0–4–2 are investigated. The experimental results obtained at bombarding energies below the Coulomb barrier are found to be in accord with the theory of Coulomb excitation. The distributions at higher bombarding energies are discussed in the light of a more general description, based on the sudden-impact approximation. It is pointed out that the method may be useful for spin determinations and for studies of nuclear reaction mechanisms. (auth)

**32421** ON THE ANGULAR DISTRIBUTION OF $\gamma$-QUANTA IN INELASTIC $\alpha$-SCATTERING. Kurt Alder (Univ. of Basel) and Aage Winther. Nuclear Phys., 37: 194-200(Aug. 1962). (In English)

The angular distribution of $\gamma$ quanta emitted after inelastic $\alpha$ scattering by nuclei is calculated, as a function of the scattering angle and suitable excitation amplitudes of the different possible magnetic substates. In the sudden-impact approximation the explicit result is shown in tables and figures, for the case that an $\alpha$ or $\gamma$ counter having cylindrical symmetry around the beam direction is used. (auth)

**32422** DIRECT INTERACTION MECHANISM IN (d,$\alpha$) REACTIONS. S. Micheletti and J. B. Mead (Univ. of Pittsburgh). Nuclear Phys., 37: 201-14(Aug. 1962). (In English)

The reactions $Y^{89}(d, \alpha)Sr^{87}$, $Zr^{90}(d, \alpha)Y^{88}$, $Zr^{92}(d, \alpha)Y^{90}$, $Pb^{208}(d, \alpha)Tl^{206}$, and $Bi^{209}(d, \alpha)Pb^{207}$ were studied with 15-Mev deuterons. Alpha particle angular distributions were obtained for four energy levels in $Sr^{87}$. The alpha spectra were compared with a qualitative model based on a double-pickup mechanism. Angular distributions were analyzed using two-nucleon stripping theory. (auth)

**32423** GAMMA-RAY TRANSITIONS IN $C^{11}$ FROM THE $B^{10}(d,n\gamma)C^{11}$ REACTION. R. M. Freeman (Cavendish Lab., Cambridge, Eng.). Nuclear Phys. 37: 215-25(Aug. 1962). (In English)

The detection of gamma rays in coincidence with neutrons whose energies are selected by time-of-flight enables the decay scheme of levels below 7 Mev to be partially determined. The few n-$\gamma$ angular correlations measured are not markedly anisotropic. Comparison with the decay scheme for $B^{11}$ suggests that the ordering of levels in the two nuclei is the same except for the inversion of the doublet between 6 and 7 Mev. (auth)

**32424** THE ENERGY LEVELS OF $Mg^{24}$. A. R. Quinton and G. P. Lawrence (Australian National Univ., Canberra). Nuclear Phys., 37: 244-9(Aug. 1962). (In English)

The reaction $Al^{27}(p, \alpha)Mg^{24}$, induced by protons of energy 11 Mev, leads to levels of $Mg^{24}$ at excitation energies of 1.368, 4.122, 4.232, 5.251, 6.010, 6.430, 7.344, 7.594, 7.797, 8.116, (8.36), and (8.44) Mev. (auth)

**32425** DECAY OF YTTRIUM-85. A. P. Patro and B. Basu (Saha Inst. of Nuclear Physics, Calcutta). Nuclear Phys., 37: 272-8(Aug. 1962). (In English)

The half life and radiations of yttrium-85 are studied with scintillation beta and gamma spectrometers. The half life is measured to be 3.25 ± 0.25 hr. Three positron groups are found with end energies 2.1 ± 0.10, 1.54 ± 0.10, and 1.16 ± 0.10 Mev. Several gamma rays are found at energies 230, 510 (composite includes annihilation), 720, and 920 kev. On the basis of sum and coincidence studies, a level scheme for $Sr^{85}$ is proposed. (auth)

**32426** QUASI-DEUTERON PRODUCTION BY DIPOLE $\gamma$-RAYS IN $^4He$. Arne Reitan (NORDITA, Copenhagen). Nuclear Phys., 37: 279-82(Aug. 1962). (In English)

The total cross section for direct absorption of dipole $\gamma$ rays by neutron-proton pairs is evaluated for helium on the assumption of shell-model initial-state wave functions. The results are compared with the corresponding experimental cross section. (auth)

**32427** (p,p'$\gamma$) TRIPLE ANGULAR CORRELATION SURFACES. Eric Sheldon (Eidgenössische Tehnische Hochschule, Zurich). Nuclear Phys., 37: 302-11(Aug. 1962). (In English)

The statistical theory of triple angular correlation is applied to proton inelastic scattering on $Fe^{56}$, $Cr^{52}$, $Ni^{58}$, and $Mg^{24}$ at incident energies around 4 Mev. Numerical results for the correlation function $W(\theta_{p'}, \theta_\gamma, \phi = 0°)$ are represented in the form of correlation surfaces plotted as contour maps of equivalued W in terms of $\theta_{p'}$ and $\theta_\gamma$, referred to the incident proton direction in the center-of-mass system. Data are also given for proton and $\gamma$ angular distributions and the theoretical results are compared with experimental values. (auth)

**32428** SHELL THEORY AND $Pb^{208}$ (II). W. T. Pinkston (Vanderbilt Univ., Nashville). Nuclear Phys., 37: 312-18 (Aug. 1962). (In English)

The $3^-$ and $4^+$ energy levels predicted for $Pb^{208}$ by the shell model in the Tamm-Dancoff approximation are studied. The calculated energy of the $3^-$ level is not in agreement with experiment. The predicted wave function is used to calculate the E3 transition rate to the ground state. The rate is found to be too small by a factor of about 20. The energies and wave functions for the $4^+$ levels are calculated. A level of the correct energy is predicted but the E4 transition rate to the ground state is 30 to 100 times too small. (auth)

**32429** NEUTRON-GAMMA ANGULAR CORRELATION STUDIES FROM THE REACTION $Be^9(d,n\gamma)B^{10}$. J. B. Garg, N. H. Gale, and J. M. Calvert (Univ. of Manchester, Eng.). Nuclear Phys., 37: 319-31(Aug. 1962). (In English)

A study is made of the $Be^9(d,n\gamma)B^{10}$ reactions. Two neutron groups are observed in coincidence with $\gamma$ rays, and these are shown to correspond to the levels in $B^{10}$ at 3.58 and 5.16 Mev excitation. Angular correlation measurements made at deuteron energies of 2.65, 3.3, and 4.4 Mev show that these levels are of even parity. While a spin of 1 cannot be excluded for the 5.16-Mev level, the evidence favors a spin of 2, supporting the belief that this is the second-lowest T = 1 state in $B^{10}$. (auth)

**32430** NOTE ON THE QUASI-DEUTERON MODEL FOR NUCLEAR PHOTO-DISINTEGRATION. S. Fujii (Nihon Univ., Tokyo). Nuovo cimento (10), 25: 995-1007(Sept. 1, 1962). (In English)

Noting the difference between the proton-neutron pair in the nucleus and deuteron, the cross section for photon absorption by all the proton-neutron pairs is calculated. The photonuclear interaction is taken to be of the classical type so as to mark the connection of the high-energy nuclear photoeffect with the low-energy effect. The calculation is performed taking the Pauli principle into consideration both in the initial and the final states. The dependence of the cross section on the short-range correlation between the nucleons in the nucleus is discussed. It is also shown how the cross section varies with photon energy. The range of validity of the quasi-deuteron model for nuclear photodisintegration is suggested. (auth)

**32431** THE DECAY OF $^{29}P$. Ole Loensjoe (Universitetet, Oslo, Blindern, Norway). Phys. Norvegica, 1: No. 1, 41-5(1962). (In English)

The gamma spectrum accompanying the positron decay of $P^{29}$ was measured. The following branching ratios were found (log ft values in parenthesis): to the ground state of $Si^{29}$ 0.984 ± 0.003 (3.72 ± 0.02), to the 1.28 Mev level 0.011 ± 0.003 (4.93 ± 0.14), to the 2.03 Mev level < 0.0007 (>5.5), and to the 2.43 Mev level 0.0055 ± 0.002 (4.15 ± 0.2). The intensities of the gamma transitions from the 2.43 Mev level to the levels at 1.28 and 2.03 Mev are less than 66 and 20%, respectively of the ground state transition. The results are in disagreement with published predictions on the basis of a rotational collective model. (auth)

**32432** RESONANCES FOR PROTON CAPTURE IN $^{28}Si$ AND $^{32}S$ BETWEEN 500 kev AND 1900 kev. Ole Loensjoe (Universitetet, Oslo, Blindern, Norway). Phys. Norvegica, 1: No. 1, 47-51(1962). (In English)

The yields of the reactions $Si^{28}(p,\gamma)P^{29}$ and $S^{32}(p,\gamma)S^{33}$ were determined by measuring the number of radioactive

nuclei produced. In $Si^{28}$ one resonance only is seen, at $E_p$ = (1645 ± 5) kev, Γ = (54 ± 3) kev, $\theta^2$ = 0.38, and $\Gamma_\gamma$ = (1 ± 0.5) ev. In $S^{32}$ four resonances are found at $E_p$ = (579.5 ± 0.5) kev, Γ < 1 kev, $\omega\gamma = (1.1 \pm 0.3)\cdot 10^{-2}$ ev; at $E_p$ = (587.6 ± 0.5) kev, Γ < 1 kev, $\omega\gamma = (3 \pm 1)\cdot 10^{-2}$ ev; at $E_p$ = (1753.8 ± 0.7) kev Γ = (1.5 ± 0.6) kev, $\omega\Gamma_\gamma = (7 \pm 2)\cdot 10^{-2}$ ev, and at $E_p$ = (1890 ± 5) kev, Γ < 15 kev and $\Gamma_\gamma = (11 \pm 4)\cdot 10^{-2}$ ev. The level in $Cl^{33}$ corresponding to the resonance at 579.7 kev is shown to decay directly to the ground state. The 587.6 kev resonance decays by 50% through a level at 0.80 Mev and by 50% directly to the ground state. (auth)

**32433** EFFECTIVE RANGE THEORY OF MULTICHANNEL REACTIONS IN THE CHAIN APPROXIMATION METHOD. Yasunori Fujii (Nihon Univ., Tokyo). Progr. Theoret. Phys., (Kyoto), 27: 849-81(May 1962). (In English)

The effective-range theory for two- and three-channel reactions is investigated in the chain approximation method. Explicit formulas are derived for the cases in which there are two scalar particles with equal masses in the S-state, or one baryon and one meson either in the S- or P-state, in each channel. In particular the formulas are obtained by which the effective ranges for coupled systems are given in terms of the scattering lengths of coupled systems and the effective ranges for isolated channels. These formulas are expected to be tested by experiments rather unambiguously, since some of scattering lengths are known and the effective ranges for isolated channels, if defined appropriately, are determined only kinematically, independent of the strengths of interactions. (auth)

**32434** AXIAL ASYMMETRY OF THE NUCLEUS AND THE TRIPLE SPLIT GIANT RESONANCE. Kazuto Okamoto (Tohoku Univ., Sendai). Progr. Theoret. Phys. (Kyoto), 27: 1073-5(May 1962). (In English)

The triple splitting of the giant resonance is calculated for several nuclei having $20 \leq A \leq 200$ on the basis of the axially asymmetric model. (T.F.H.)

**32435** FIRST $0^+$ STATE IN $O^{16}$. Kiyomi Ikeda, Toshio Marumori, and Kenjiro Takada (Nihon Univ., Tokyo and Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 27: 1077-8 (May 1962). (In English)

The excitation energy of the first $0^+$ state in $O^{16}$, as well as the matrix element value for the transition from this level to the ground state, are discussed, using the method of eigenmodes. It is concluded that two-pair excitations yield the dominant contribution to the level. (T.F.H.)

**32436** STUDY AND IDENTIFICATION OF ISOTOPES BY NUCLEAR MAGNETIC RESONANCE. René Brocard. Rev. gén. électronique, No. 179, 55-8(Oct. 1961). (In French)

The basic principles of nuclear magnetic resonance are briefly described and illustrated by a typical experiment. The type of signals received by nuclear magnetic spectrometers is shown and a sample schematic of such a spectrometer is given. (J.S.R.)

**32437** POLARIZATION OF 3 Mev PROTONS ELASTICALLY SCATTERED ON $C^{12}$. Yu. A. Nemilov and L. A. Pobedonostsev. Zhur. Eksptl'. i Teoret. Fiz., 43: 382-4(Aug. 1962). (In Russian)

The angular dependence of polarization of protons elastically scattered on $C^{12}$ is investigated. The results of the experiments are compared with theoretical calculations. It is shown that due to the high sensitivity of polarization to phase shifts the latter may serve as an exact criterion for performing phase shift analysis. (auth)

**32438** POLARIZATION OF 3.5 Mev NEUTRONS UPON SCATTERING. P. S. Otstavnov and V. I. Popov. Zhur. Eksptl'. i Teoret. Fiz., 43: 385-7(Aug. 1962). (In Russian)

For a number of elements, mainly with a mass number A < 65, measurements are carried out on the polarization of neutrons produced in the d + d reaction and scattered into an angle $\theta_{lab}$ = 30°. The dependence of the polarization on A is a continuous function. (auth)

**32439** ANGULAR DISTRIBUTION OF PROTONS FROM THE (α,p)-REACTIONS INDUCED BY 13-15 Mev α-PARTICLES. M. P. Konstantinova, E. V. Myakinin, A. M. Petrov, and A. M. Romanov (Ioffe Inst. of Physics and Tech., Leningrad). Zhur. Eksptl'. i Teoret. Fiz., 43: 388-93(Aug. 1962). (In Russian)

Experimental angular distribution curves are presented for 1) $p_0$ group protons from the reactions $Li^6$ (α, p) $Be^9$ and $Li^7$ (α, p) $Be^{10}$ induced by 13.6 and 14.7 Mev α particles, 2) protons of the $p_1$ and $p_2$ groups from the reaction $F^{19}$ (α, p) $Ne^{22}$ with 14.7 Mev α particles and 3) $p_1$ group protons from the reaction $Al^{27}$ (α, p) $Si^{30}$ with 14.7 Mev α particles. A characteristic feature of the indicated distributions is the asymmetry relative to the angle 90° (cms) and considerable increase of the reaction cross sections for large proton emission angles (θ > 120°). The final nuclei in the $F^{19}$ (α, p) $Ne^{22}$ and $Al^{27}$ (α, p) $Si^{30}$ reactions involving 13-15 Mev α particles are predominantly in the excited state. The intensity of the $p_0$ proton group is much smaller than that of the $p_1$ and $p_2$ groups. The nature of the angular distribution of the $p_2$ proton group from the $F^{19}$ (α, p) $Ne^{22}$ reaction does not contradict the assumption that the second excited level in $Ne^{22}$ has the character $2^+$. (auth)

**32440** SOME CHARACTERISTICS OF THE SPECTRA OF RESONANCE ABSORPTION OF 23.8 kev γ-RAYS BY $Sn^{119}$ NUCLEI. V. A. Brukhanov, N. N. Delyagin, A. A. Opalenko, and V. S. Shpinel (Moscow State Univ.). Zhur. Eksptl'. i Teoret. Fiz., 43: 432-7(Aug. 1962). (In Russian)

The probabilities for absorption of 23.8 kev γ quanta by $Sn^{119}$ without recoil energy losses are measured for 14 tin-containing compounds at 77 and 300°K temperature. A very weak temperature dependence of this probability was observed for some of the compounds. The main regularities pertaining to the magnitude of the chemical isomer shifts and the magnitude of quadrupole interaction are qualitatively interpreted on basis of simple assumptions regarding the nature of the chemical bond in tin compounds. The interpretation proposed confirms a suggestion previously made that excitation of the $Sn^{119}$ causes an increase of the effective radius of the nuclear charge distribution. (auth)

**32441** INVESTIGATION OF THE MILLISECOND ISOMERS DETECTED IN NUCLEAR REACTIONS INVOLVING FAST PROTONS. A. M. Morozov and V. V. Remaev (Inst. of Chemical Physics, Academy of Sciences, Ukrainian SSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 438-47(Aug. 1962). (In Russian)

Results are presented from an investigation of short-period isomeric activities previously detected by irradiating Ti, Sr, Y, Zr, Ta, Hg (two activities), Pb, and Bi by a pulsed beam of fast ($E_p$ = 19.2 Mev) protons. An analysis of the experimental data revealed the following reactions yielding millisecond isomers: $Ti^{46}(p,n)V^{46m}$, $Sr^{88}(p,n)Y^{88m}$, and $Y^{89}(p,pn)Y^{88m}$. Identification of the following reactions is also confirmed: $Zr^{90}(p,n)Nb^{90m_1}$, $Pb^{208}(p,n)Bi^{208m}$, $Bi^{209}(p,pn)Bi^{208m}$, and $Ge^{72}(p,pn)Ge^{71m}$. More accurate values of the decay period and radiation energies have been obtained in all cases investigated. The dependence of the cross section for $Y^{83m}$ (from strontium) and $Nb^{90m_1}$

isomer production on proton energy is also measured. The $V^{48m}$ and $W^{180m}$ isomer production cross section is measured for 19.2 Mev proton energies. An analysis of the available data reveals that the experimental values of the cross section for production of $Nb^{90}$ nuclei in the isomeric and ground states in the reaction $Zr^{90}(p,n)Nb^{90}$ (proton energy up to 12 Mev) are consistent with the assumption of formation of a compound nucleus. (auth)

**32442** PECULIARITIES OF MOSSBAUER SPECTRA OF TIN-ORGANIC COMPOUNDS AND THE ROLE OF THE NEAREST CHEMICAL BONDS IN THE MOSSBAUER EFFECT. V. A. Bukhanov, V. I. Goldanskii, N. N. Delyagin, L. A. Korytko, E. F. Makarov, I. P. Suzdalev, and V. S. Shpinel (Inst. of Chemical Physics, Academy of Sciences, USSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 448-52(Aug. 1962). (In Russian)

It has been found in investigating the Mossbauer effect in tin-organic compounds that singlet Mossbauer lines appear in compounds with four identical substituents ($SnCl_4$, $Sn(C_6H_5)_4$) whereas if different substituents ($R_iSn\,X_{4-i}$) are present in the molecule a very strong doublet splitting of the Mossbauer lines occurs (the two peaks sometimes being different in intensity and width). The Mossbauer effect has been observed in amorphous media (tin containing glass) for the first time. Some data are obtained which indicate that the decisive factor determining the shape of the Mossbauer spectra (isomer shift and quadrupole splitting) are the molecular bonds closest to the tin nuclei. (auth)

**32443** $\beta$- AND $\gamma$-SPECTRA OF $Rh^{97}$. V. L. Chikhladze, D. E. Khulelidze, and Yu. A. Ryukhin (Inst. of Physics and Tech., Academy of Sciences, Georgian SSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 453(Aug. 1962). (In Russian)

Results of experimental determination of the $\beta$ and $\gamma$ spectra of $Rh^{97}$ are presented. The end point energy of the $\beta^+$ spectrum is 2050 kev. $\gamma$ lines with energies at 185, 255, and 420 kev have also been detected. (auth)

**32444** NONADIABATIC CORRECTIONS TO THE ROTATIONAL SPECTRUM OF ATOMIC NUCLEI. Yu. T. Grin and I. M. Pavlichenkov. Zhur. Eksptl'. i Teoret. Fiz., 43: 465-72(Aug. 1962). (In Russian)

The coefficient B in the expansion of the nuclear rotational energy in angular momentum is calculated. The problem is solved in the quasiclassical approximation for particles in an oscillator potential, pair correlation being taken into account. The theoretical values of B are compared with the experimental ones. (auth)

**32445** APPLICATION OF AN OPTICAL POTENTIAL FOR ESTIMATING THE NEUTRON ABSORPTION COEFFICIENT OF AN EXCITED NUCLEUS. V. A. Zhmailo. Zhur. Eksptl'. i Teoret. Fiz., 43: 473-5(Aug. 1962). (In Russian)

The parameters of the optical potential employed to describe the interaction between a neutron and excited ($E_{ex} \sim 10$ to 20 Mev) nucleus are estimated. The cross section for neutron absorption $\sigma_c(\epsilon_n, E_{ex})$ by an excited nucleus is also estimated. For $\epsilon_{ex} \sim 20$ Mev, incident neutron energy $\epsilon_n \sim 1-2$ Mev, $A \sim 100$, $\sigma_c(\epsilon_n, \epsilon_{ex})$ is found to increase by one and a half to two times compared with $\sigma_c(\epsilon_n, E_{ex} = 0)$. (auth)

**32446** NEUTRON-PROTON INTERACTION ENERGY IN ODD-ODD NUCLEI. P. E. Nemirovskii. Zhur. Eksptl'. i Teoret. Fiz., 43: 530-5(Aug. 1962). (In Russian)

The neutron–proton interaction energy in odd-odd nuclei, $\Delta_{np}$, is computed on the basis of nuclear binding energy data. The relation between this energy and the (shell) state of the proton and neutron is considered. The energy of the center of gravity of the ground multiplet of light nuclei is calculated and it is shown that in a number of cases this energy is the same as $\Delta_{np}$. (auth)

**32447** ACCURACY OF THE BOGOLYUBOV METHOD IN THE THEORY OF EVEN-EVEN NONSPHERICAL NUCLEI. A. Pawlikowski and V. Rybarska (Pavlikovskii) (Joint Inst. of Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 543-50(Aug. 1962). (In Russian)

The following model is analyzed: interaction of n particles on $\Omega$ doubly degenerate equidistant levels with potential. The eigenvalue problem has been solved exactly in this case. The results are compared with the calculations by the approximate (u, v) transformation method proposed by Bogolyubov. Calculations by taking and not taking into account the blocking effect are performed for excited states. Moreover, a method of projecting the approximate vectors on the sub-space of $n$ particles is applied. The problem of accuracy of the methods employed for investigating pair interaction in even-even nonspherical nuclei is also considered. (auth)

**32448** SYMMETRICAL SHAPES OF EQUILIBRIUM IN A SHARP SURFACE NUCLEUS MODEL (THE LIQUID DROP MODEL). V. M. Strutinskii, N. Ya. Lyashchenko, and N. A. Popov. Zhur. Eksptl'. i Teoret. Fiz., 43: 584-94(Aug. 1962). (In Russian)

The main results of calculations of symmetrical equilibrium shapes of nuclei are presented. The integral differential equation for the equilibrium shapes is solved by an iteration method. (auth)

**32449** POLARIZATION CALCULATION BY THE EQUIVALENT PHOTON METHOD. A. M. Badalyan. Zhur. Eksptl'. i Teoret. Fiz., 43: 608-12(Aug. 1962). (In Russian)

It is shown that the equivalent photon method can be employed for calculating polarization effects. For electron bremsstrahlung in the field of a nucleus the polarizations of the radiation and final electron are calculated. (auth)

**32450** ON CALCULATION OF THE PARAMAGNETIC RELAXATION TIME IN VISCOUS MEDIA. S. V. Karyagin and N. N. Korst. Zhur. Eksptl'. i Teoret. Fiz., 43: 613-16(Aug. 1962). (In Russian)

On basis of the kinetic equation for the mean value of an arbitrary spin operator, an equation set is derived for the components of a spin $I \geq 1$ when the interaction with the medium is a quadrupole term. The equation set is solved for the particular case of a $\frac{3}{2}$ spin. It is shown that relaxation of any spin component is determined by I different exponents (for integral spins) or $I + \frac{1}{2}$ exponents (for half-integral spins). (auth)

**32451** SPLITTING OF A PHOTON INTO TWO PHOTONS IN THE COULOMB FIELD OF A NUCLEUS. A. P. Bukhvostov, V. Ya. Frenkel, and V. M. Shekhter (Ioffe Inst. of Physics and Tech., Leningrad). Zhur. Eksptl'. i Teoret. Fiz., 43: 655-60(Aug. 1962). (In Russian)

The cross section for transformation of a photon into two photons in the Coulomb field of a nucleus is determined for the case when the incident photon energy is either small or large compared to the electron mass. In the latter case the calculations are carried out by the Weizsacker–Williams method. (auth)

**32452** GIANT RESONANCE OF SPIN WAVE EXCITATION IN ATOMIC NUCLEI. V. V. Balashov and A. V. Tulinov (Moscow State Univ.). Zhur. Eksptl'. i Teoret. Fiz., 43: 702-5(Aug. 1962). (In Russian)

The main properties of collective spin wave excitations in nuclei are considered. Concrete calculations are carried

out for the $Ca^{40}$ nucleus. It is shown that due to the high degree of smearing out of the spin wave excitations, the width of the fast proton inelastic scattering peak should considerably exceed that of the photoabsorption giant resonance. (auth)

**32453** TRANSFER OF NEGATIVE MESONS FROM HYDROGEN TO NUCLEI OF OTHER ELEMENTS. S. S. Gershtein (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 43: 706-19(Aug. 1962). (In Russian)

It is shown that the high probability for transfer of negative mesons from hydrogen to nuclei of other elements is connected with the interaction of molecular terms corresponding to charge exchange. The cross section for $\mu$-meson transfer from the K orbit of hydrogen to carbon and oxygen nuclei is calculated and the cascade transition of the mesic atoms thus formed to the ground state is considered. It is shown that the probability for transfer of $\mu^-$ mesons to He is very small inasmuch as the $p\mu$He system is an exceptional case of $p\mu Z$ systems due to absence of intersection of terms corresponding to charge exchange from the hydrogen K orbit. It is pointed out that the probability for inelastic collisions of the second kind for hydrogen mesic atoms in highly excited states with protons is very large and leads to a rapid transition of the mesic atoms to lower energy levels. This effect may be important for explaining the small value of the $\pi^-$ lifetime in hydrogen. (auth)

## Particle Accelerators

*Refer also to abstracts 31718, 31737, 31741, 31775, 31776, 31778, 31928, and 31945.*

**32454** (60-RL-2345E) HIGH-ENERGY NUCLEAR PHYSICS RESEARCH PROGRAM. Final Report. W. B. Jones (General Electric Co. Research Lab., Schenectady, N. Y.). Jan. 1960. Contract N7onr-332(01). 7p.

Activities in a program of high-energy accelerator development and research in high-energy nuclear physics are summarized. The program was initiated Dec. 1, 1946, and is now terminated. During the investigation, a 300-Mev nonferromagnetic synchrotron was developed, and a program of research in high-energy physics was carried out in connection with the 300-Mev synchrotron and the 100-Mev GE betatron. These activities are reviewed briefly, and the titles of relevant technical reports and publications are listed along with the appropriate references. (auth)

**32455** (CERN-62-12) SUR LA POSSIBILITÉ DE MAINTENIR DEUX SYSTÈMES DE PAQUETS SIMULTANÉMENT STABLES VIS-À-VIS DES OSCILLATIONS SYNCHROTRONIQUES ET CIRCULANT SUR DES ORBITES DIFFÉRENTES DANS UN SYNCHROTRON À GRADIENTS ALTERNÉS. (On the Possibility of Keeping Two Systems of Beams Fixed Simultaneously Against the Synchrotronic and Circular Oscillations on Different Orbits in an Alternating Gradient Synchrotron). A. Chabert (European Organization for Nuclear Research, Geneva). Feb. 23, 1962. 35p.

After the acceleration cycle, it would be advantageous to be able to separate the beam into two parts. The first beam system would be the usual system, but some particles would be used to produce a new beam system circulating on a different orbit. The manner of transferring the particles of the first system to the second orbit is not considered, but an attempt is made to determine under what conditions two beam systems simultaneously stable with respect to the synchrotron oscillations could be obtained. After the magnetic configuration is determined, the production of two stable orbits necessitates the presence of two acceleration systems characterized by different fundamental frequencies. The basic equations were derived, and an analytical study of the problem was made. Then an analog and numerical study of the orbit stabilities was carried out, and the theoretical and experimental results were compared. It was shown that two beams could be simultaneously obtained. The approximate characteristics of these two systems could be given with the aid of theoretical expressions which take into consideration the numerical results. (J.S.R.)

**32456** (DESY-A2.90) UBER DAS SPEKTRUM UND DIE WINKELVERTEILUNG DER SYNCHROTRON-STRAHLUNG. (The Spectrum and Angular Distribution of Synchrotron Radiation). (Deutsches Elektronen-Synchrotron, Hamburg). July 3, 1962. 29p.

As a supplement to the work of Tomboulian and Bedo, the functions $P(\psi,t)$ and $P(\psi,\lambda,t)$ were determined on the basic consideration of the time laws in order to obtain information on the angular distribution of synchrotron radiation. The angular dependence and the spectrum of synchrotron radiation is first investigated with the calculation of the function $\bar{P}(\psi)$. In order to find a relationship between the angular distribution and the wave length dependence, the function $\bar{P}(\psi,\lambda)$ was then determined. (J.S.R.)

**32457** (DESY-A2.91) VORBÜNDELUNG DES DESY-INJEKTORS AUF 500 MHz. (Pre-Bunching of the DESY Injectors to 500 MHz). U. Timm (Deutsches Elektronen-Synchrotron, Hamburg). July 6, 1962. 34p.

It was shown that there are a series of possibilities to prebunch the linac beam at the synchrotron frequency. Technically the simplest and also the most effective is prebunching by velocity modulation at 500 MHz alone (PB 0.5). All methods of chopping give, on the other hand, less usable current by a factor of approximately 3. The best method is the combination of magnetic lens with the existing prebunching at 3 BHz (PB 3.0 + ML 0.25). An evaluation of the technical data shows that this method can be accomplished only with difficulty below PB 0.5. The advantage of the latter method is that all bunches are free of current. (tr-auth)

**32458** (LAL-1035) LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE RAPPORT D'ACTIVITE (OCTOBRE 15, 1961–AVRIL 15, 1962). (Linear Accelerator Laboratory Report of Activities for October 15, 1961–April 15, 1962). D. Frerejacque (Paris. Université, Orsay. Ecole Normale Supérieure. Faculté des Sciences). Apr. 15, 1962. 66p.

The semi-annual progress report on the activities of the Linear Accelerator Laboratory is presented with a survey of the work done by eight work groups–operation of the linear accelerator, high energy experimental physics, low energy experimental physics, technology group, electronics group, hyperfrequency research group, magnet research group, radiation monitoring, and hot chemistry group. The subjects discussed are beam collection, characteristics of accelerator operation, spectroscopy of $N^{14}$, electron decay of $Be^9$, excited levels of $Be^9$, proton and deuteron spectra from electron and photodecay of $C^{12}$, energy levels and summation rule for $O^{16}$, photoproduction of $\pi$ mesons, spectroscopy of $Al^{27}$, elastic scattering on $Cr^{52}$, inelastic scattering cross sections of $Ca^{40}$, polarization of recoil protons, photoproduction of charged $\pi$ mesons, properties of Faraday cylinders and secondary electron and induction masers, fast pulse circuits, and monitoring circuits and devices. The publications of the Laboratory personnel during this period are reported. (J.S.R.)

**32459** (UCRL-10067) ELECTROSTATIC DEFLECTOR CALCULATIONS FOR THE BERKELEY 88-INCH

CYCLOTRON. Alper A. Garren, David L. Judd, Lloyd Smith, and Hans A. Willax (California. Univ., Berkeley. Lawrence Radiation Lab.). May 4, 1962. Contract W-7405-eng-48. 57p.

Early computer calculations showed that an electrostatic channel would have to be very narrow to cause sufficient deflection at high energy. One alternative considered was a system of three electrostatic channels in series, acting as a one-turn regenerative extractor. Such a system could easily achieve the required deflection, but at the expense of simplicity. A magnetic channel to reinforce the electrostatic channel likewise appeared difficult for a variable-energy machine. Detailed studies of a simple electrostatic channel began with development of an analytic-graphical method of calculating channel efficiency. By this method the acceptance can be estimated as a function of radial turn separation, amplitude and frequency of radial oscillations, and channel geometry. A computer code was then developed to compute channel shapes and calculate acceptance more accurately by following the fate of a representative sample of orbits in the presence of the channel. Use of this code indicated that highest acceptance would be obtained if the channel entrance is set out at 39 in. provided the resonances at $\nu_r = 1$ and $\nu_r = 2\nu_z$ could be safely traversed, as was believed possible. Some calculations on transition through the $\nu_r = 2\nu_z$ resonance are presented. (auth)

**32460** (UCRL-10069) METAL GASKETS FOR THE BERKELEY 88-INCH CYCLOTRON. Ralph Peters (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 27, 1962. Contract W-7405-eng-48. 10p.

The Berkeley 88-in. cyclotron uses metal gaskets in a number of places where rubber would normally be used, because rubber probably would fail as a result of radiation damage. There are several large openings sealed with metal gaskets. Steel serrations biting into Cu make the seal between the magnet pole and the main vacuum tank. One of these seals has failed. Tin-plated Fe wire is used extensively as the gasket material. By sanding with 120-grit paper a suitable surface finish for sealing is provided. Metal gaskets work best when they are used between very rigid components. Care must be taken to place and hold the wire in the desired place while making a seal. (auth)

**32461** THE BLOCKING INDUCTOR OF THE SUPPLY CIRCUIT FOR THE MAGNETS OF THE ITALIAN 1000 Mev SYNCHROTRON. R. Marenesi, G. Sacerdoti, and R. Toschi (CNRN, Rome). Elettrotecnica, 47: 432-42(1960). (In Italian)

The magnet of the Italian 1000 Mev synchrotron is fed by direct current and superposed alternating current. In series to the continuous current feed an antiresonant circuit which blocks the alternating current is superposed. The blocking inductor has a continuous current of 2715 amp and is exposed to an alternating voltage of 4615 v. The design of this inductor is described. After an indication of the basic criteria and the establishment of the inductance value, the type of construction, without iron, is justified. Then the construction data are given to illustrate the problems encountered and solved. (tr-auth)

**32462** DEVICE FOR THE ACCELERATION OF ELECTRONS. Max Sempert and Rolf Wideroee (to Aktiengesellschaft Brown, Boveri and Cie.). Swiss Patent 348,485. Oct. 14, 1960.

A device for the acceleration of electrons along a circular orbit with a scattering plate permeated by the deflected electrons is characterized in that the thickness of the scattering plate in the direction normal to the plane of the circular orbit can be altered. (OTS)

## Plasma Physics and Thermonuclear Processes

*Refer also to abstracts 31701 and 31715.*

**32463** (58-RL-2070) FREE PARTICLE TRAJECTORIES IN TIME-DEPENDENT AXIALLY SYMMETRIC ELECTRIC AND MAGNETIC FIELDS. H. Hurwitz, Jr. (General Electric Co. Research Lab., Schenectady, N. Y.). Sept. 1958. 30p.

The Hamiltonian formulation is used to demonstrate certain of the elementary properties of the motion of charged particles in time-dependent axially symmetric electric and magnetic fields. Use is made of the equivalent magnetic potential which governs the free particle trajectory in the r,z plane. The usual formulas for orbit drifts and adiabatic invariants are derived by means of action and angle variables. Application is also made to nonadiabatic processes. (auth)

**32464** (60-RL-2379E) SINGLE-PARTICLE LOSSES FROM CUSPED GEOMETRIES. S. Tamor (General Electric Co. Research Lab., Schenectady, N. Y.). Mar. 1960. 9p.

An upper bound on the single particle losses from cusped magnetic confinement systems is obtainable from equilibrium considerations. The method is applied in detail to a plane system and an estimate of the effective leakage width of the cusp obtained. (auth)

**32465** (61-RL-2626E) STUDIES OF A NEUTRON-PRODUCING MAGNETICALLY COMPRESSED DEUTERIUM PLASMA. L. M. Goldman, H. C. Pollock, and W. F. Westendorp (General Electric Co. Research Lab., Schenectady, N. Y.). Feb. 1961. 29p.

A device for plasma heating and containment is discussed which has led to the production of neutron pulses which are of possible thermonuclear origin. The method, which employs a rapidly rising magnetic field in a cylindrical mirror geometry to heat a deuterium plasma, was used initially in the Scylla experiment of the Los Alamos Scientific Lab. Two experimental facilities in the GE Research Lab. are described. Some observations of heated plasmas were made by optical, x-ray, electrical, and nuclear techniques; and the parameters for maximizing neutron output were explored in a preliminary way. (auth)

**32466** (61-RL-2725E) A BRIEF DISCUSSION OF SOME FACTORS RELATED TO THE ECONOMICS OF STEADY-STATE DEUTERIUM MIRROR MACHINE OPERATION. D. J. BenDaniel (General Electric Co. Research Lab., Schenectady, N. Y.). May 1961. 22p.

A quantitative discussion, based on best available theoretical and experimental results of the regimes of net power output and power density achievable from a deuterium operated mirror machine is presented. It is shown that economical operation is to be expected only for mirror ratios of the order of 10 and source energies of the order of 200 kev. It is also concluded that in order to achieve economic feasibility mirror systems must, in addition, exhibit stability for higher values of the ratio of particle pressure to magnetic field pressure ($\beta$) than present experimental data indicate. A gross estimate of the net electrical power output of a thermonuclear system is included and the sensitivity of the economics of mirror systems to the degree of energy trans-

fer from reaction products to deuterium is pointed out. (auth)

**32467** (62-RL-2922E) NONEQUILIBRIUM IONIZATION IN MAGNETOHYDRODYNAMIC GENERATORS. D. J. BenDaniel and S. Tamor (General Electric Co. Research Lab., Schenectady, N. Y.). Jan. 1962. 30p.

The steady state ionization of a gas in which the electrons are hot and the atoms cool is investigated. The rate equations governing ionization, excitation, recombination, and de-excitation are solved for a model system using rate coefficients appropriate to the Cs atom. Included are all processes involving free electrons as well as spontaneous emission and resonance trapping of radiation. No incoming radiation is assumed, and the system is assumed large compared with a collisional mean free path but optically thin except for resonance radiation. The fractional ionization is computed for a range of electron temperatures and Cs densities of interest in MHD studies. It is found that there are reasonable conditions of temperature and density under which the ionization is close to that which would prevail if the system were in equilibrium at the electron temperature. At lower temperatures or densities, the ionization decreases but is still much greater than that appropriate to the gas temperature. (auth)

**32468** (62-RL-3010E) NONEQUILIBRIUM IONIZATION IN TRANSIENT HELIUM–CESIUM DISCHARGES. D. J. BenDaniel, C. M. Bishop, W. F. Westendorp, L. M. Goldman, and H. Hurwitz, Jr. (General Electric Co. Research Lab., Schenectady, N. Y.). May 1962. 25p.

Experiments on nonequilibrium ionization using transient discharges in a diode structure containing He and Cs are described. A theory of the phenomena of nonequilibrium ionization is presented, and a discussion of the principles of the experiment is given. The experimental equipment is described and experimental results which have thus far been obtained are summarized. (auth)

**32469** (62-RL-3011E) WKB MATCHING CONDITIONS AT GRADUAL INTERFACES. I. WKB MATCHING CONDITIONS AT INTERFACES VARYING AS $X^n$. II. WKB MATCHING FACTORS FOR A RISING EXPONENTIAL BOUNDARY. D. J. BenDaniel and H. Hurwitz, Jr. (General Electric Co. Research Lab., Schenectady, N. Y.). May 1962. 20p.

Reflection coefficients are calculated for the case of a plane wave impinging on a boundary beyond which the dielectric coefficient has a form $\epsilon_0(1 - ZX^n)$ where n is a positive number, Z is a complex constant, and $\epsilon_0$ is the initial dielectric constant. Contour plots of the absolute value of the reflection coefficient are given for n = 0, 1, and 2. The asymptotic form of the solution for large X is obtained and its ratio to the WKB solution is calculated. General formulas for the reflection coefficient and the asymptotic behavior are given for arbitrary positive n and large Z. The development of WKB matching factors previously initiated is extended to the case where $\epsilon = \epsilon_0(1 - Ze^{\alpha X})$, $\alpha$ being real and positive. It is shown that the reflection coefficient is a function only of the phase of Z (not its magnitude) and the magnitude of $\alpha$. The ratio of the asymptotic solution for large X to the WKB solution is shown to be a function of $\alpha$ alone. (auth)

**32470** (62-RL-3079E) ELECTRON CONDUCTIVITY AT CYCLOTRON RESONANCE. D. J. BenDaniel and H. Hurwitz, Jr. (General Electric Co. Research Lab., Schenectady, N. Y.). July 1962. 11p.

The electron conductivity of an ionized gas for electromagnetic radiation of frequency $\omega$ circularly polarized in the right-handed sense propagating along a uniform magnetic field is estimated for a plasma of nonzero temperature. Collisions are included. It is also shown that in the limit where the collision frequency becomes small and $\omega = \omega_c$ there remains a nonvanishing real part of the form $\sigma = (ne^2/km)\,(1/v_{th})\,\alpha$ where k is the propagation constant, $v_{th}$ is the speed which characterizes the thermal spread of the electron's velocity component in the longitudinal direction and $\alpha$ is a number of order unity relatively insensitive to the actual form of the electron distribution in longitudinal speeds. (auth)

**32471** (AD-271711) MASSIVE HYPERVELOCITY PARTICLES BY ELECTRICAL MEANS. Final Summary Report, April 21, 1960–October 13, 1961. Henry H. Hilton, Paul H. Levine, Norbert N. Hankin, and Francis H. Webb (Electro-Optical Systems, Inc., Pasadena, Calif.). Nov. 13, 1961. Contract DA-04-495-ORD-2000. 146p. (EOS-1470-Final)

An investigation was made of techniques for obtaining hypervelocity particles by electrical means. Dense metal-derived plasmas with particle densities greater than $10^{18}$ particles/$cm^3$ were created by exploding aluminum and lithium wires with an initial mass of the order of a milligram where the region of peak luminosity has a velocity of 20 to 30 km/sec and with luminous fronts moving, typically, at velocities between 40 to 50 km/sec. Experimental and theoretical studies were made of the coupling of small projectiles to these gas flows. Small projectiles of $Al_2O_3$ were accelerated to a velocity of about 10 km/sec, although some fragmentation of the original projectile was observed. Energy transfers to the wire and eroded material of 30 to 60% of that initially stored on the condenser were achieved. Energy densities from 2 to 30 times those required for vaporization were achieved. In the projectile projection experiments, the initial sound velocity of the plasma was of the order of 10 km/sec and the projectiles were accelerated to velocities between 6 and 10 km/sec. (M.C.G.)

**32472** (AFCRL-731) ON THE PROBLEM OF OVERTAKING IN A VELOCITY DISTRIBUTED ELECTRON STREAM. Report No. 19. K. H. B. Wilhelmsson (Chalmers Tekniska Högskola, Goteborg. Forskningslaboratorium för Elektronik). 1961. Contract AF 61(052)-159. 8p. (AD-271734)

The problem of overtaking in a velocity distributed one-dimensional uniform electron stream for the special case where the velocity-spread is small compared with the velocities associated with the wave motion is studied. A condition for overtaking in this case which demonstrates the destructive effect of a velocity spread on the regular oscillations of the electrons when the amplitudes become large is stated. (auth)

**32473** (AFCRL-748) A THEORY OF INCOHERENT SCATTERING OF RADIO WAVES BY A PLASMA IN A UNIFORM MAGNETIC FIELD. Report No. 21. D. T. Farley (Chalmers Tekniska Hogskola, Goteborg. Forskningslaboratorium for Elektronik); J. P. Dougherty, and D. W. Barron (Cambridge Univ., England. Cavendish Lab.). 1961. Contract AF61(052)-451. 45p. (AD-271735)

A general expression for the frequency spectrum of radio waves scattered by the random thermal fluctuations of electron density in a plasma in thermal equilibrium and in a magnetic field is derived. The derivation is based on the generalized Nyquist noise theorem. The exact result is simplified by means of an approximation which amounts to assuming the velocity of light to be infinite. It is shown that this approximation is quite adequate for ionospheric applications of the theory. Next is is proved, without appealing to any approximation, that the magnetic field can never

alter the total scattered signal power; it can only redistribute this power over the spectrum. Finally, the detailed shape of the frequency spectrum of the scattered signal is examined. Analytic expressions are given for certain limiting cases, but for the cases of most interest, numerical methods must be used. (auth)

**32474** (AFOSR-3067) THE CONTINUUM THEORY OF SPHERICAL ELECTROSTATIC PROBES. Report 605. C. H. Su and S. H. Lam (Princeton Univ., N. J.). Apr. 1962. Contract AF 49(638)-465. 45p.

A continuum theory for negatively charged spherical electrostatic probes in a slightly ionized plasma is developed. The density of the plasma is taken to be sufficiently high such that both ions and electrons suffer numerous collisions before being collected by the probe. The probe surface is assumed to be absorbing. The ion and electron temperatures may have different values but are uniform in space. By confining attention to highly negative probe potentials, the Boltzmann distribution for electron number density is shown to be the correct approximation. Under the assumption that the probe radius, $r_p$, is large compared with the electronic Debye distance, $h_e$, and that the probe potential is sufficiently negative, the structures of the potential, electron, and ion density distributions are discussed in some detail. It is found that under such circumstances the boundary condition for ion density at the probe is unimportant. Analytical behavior of the solutions are given and a simple closed-form ion-current-voltage characteristic is obtained. Numerical computation is carried out to supplement the analysis and to cover a wider range of probe sizes. Two kinds of current-voltage characteristics are constructed. One of them is specially appropriate for the determination of the ionization density. Finally, the disturbance in the plasma is found to be confined mainly to a layer adjacent to the probe. It is shown that the thickness of this layer is not of order of Debye length, whenever $P_p \gg h_e$. (auth)

**32475** (ASD-TDR-62-459) VORTEX MAGNETOHYDRODYNAMIC GENERATOR EXPERIMENTAL TEST PROGRAM. H. G. Starck (AiResearch Mfg. Co., Los Angeles). Apr. 1962. Contract AF 33(616)-7808. 64p.

A vortex type magnetohydrodynamic generator was designed and fabricated on the basis of currently available materials, and was tested to determine the feasibility of obtaining electric power from a seeded combustion gas. The combustion gas was $O_2-H_2$, seeded with KOH solution. A power output of 0.15 watts was obtained from a vortex channel which was 4 in. wide with a magnetic field strength of 4000 gauss. The gas flow rate varied from 0.4 to 0.7 pounds per minute. This result compares with a theoretical output of 29 to 60 watts which was calculated by digital computer methods. The low output was the result of material failures throughout the unit and particularly of the combustion chamber and the center electrode. The study program indicated that the small vortex MHD geperator has a significant potential provided that the material problems can be solved, either through the use of lower ionization temperature fluids or higher temperature materials. (auth)

**32476** (CAL-AF-1500-A-1) SHOCK TUNNEL STUDIES OF HIGH-ENTHALPY IONIZED AIRFLOWS. A. Q. Eschenroeder, John W. Daiber, Thaddeus C. Golian, and A. Hertzberg (Cornell Aeronautical Lab., Inc., Buffalo). July 1962. Contract AF 49(638)-952. 72p. (AFOSR-3025)

In the present study, the Cornell Aeronautical Laboratory six-foot shock tunnel is described, the effects of nonequilibrium flow in such a device are assessed, and high-enthalpy experiments involving nozzle ionization are discussed. (auth)

**32477** (DCAS-TDR-62-145) PLASMA PROPULSION BY MEANS OF A HELICAL TRANSMISSION LINE. E. B. Mayfield, R. X. Meyer, R. M. Head, and R. H. Huddlestone (Aerospace Corp. Physical Research Lab., El Segundo, Calif.). July 20, 1962. Contract AF04(695)-169. 14p. (TDR-169(3210-05)TN-1)

Experimental and theoretical studies of plasma propulsion using a helical transmission line to generate a moving magnetic field were conducted. Preliminary results from a 10-kv line encouraged the building of a similar, but larger, 25-kv line. Recent development of 0.5 $\mu$f capacitors capable of ringing at 25 kv with a frequency of 1.05 Mc and small enough to install on a transmission line made possible its construction. Results reported were obtained with the 25-kv line. The system consists of a conical electrical discharge driver, shock tube, and helical transmission line. The propellant gas is $H_2$ at an initial pressure of 175 $\mu$ (particle density $6 \times 10^{15}$ cm$^{-3}$). The shock tube driver uses a capacitor bank of 8 $\mu$f at 25 kv and rings at 250 kc/sec. At 10 cm from the ring electrode where the shock enters the transmission line, the shock has a velocity of 16 cm/$\mu$sec which decays to 3 cm/$\mu$sec as it leaves the transmission line 115 cm from the electrode. The helical line has a phase velocity of 11.3 cm/$\mu$sec and a capacitance per length of 13.8 $\mu$f/m. This gives an impedance of 0.615 ohm and an initial current of 40,700 amperes. From this the axial magnetic field is calculated to be 7100 gauss; the radial magnetic field is calculated to be 1400 gauss. Results obtained with a rotating mirror streak camera along the axis of the system show that, when the magnetic field is initiated 4 to 6 $\mu$sec behind the ionizing shock (30–40 cm in the tube), the shock velocity is maintained at the phase velocity of the transmission line—11 cm/$\mu$sec. Photomultiplier and magnetic field probes indicate that the luminous shock in the gas travels with the magnetic field at the phase velocity of the line. A pressure bar device is used to measure the change in impulse due to the magnetic field. (auth)

**32478** (LAMS-2546(Suppl.)) PRELIMINARY NOZZLING OF THE PLASMA PROPELLER. Harold W. Lewis (Los Alamos Scientific Lab., N. Mex.). Sept. 1961. Contract W-7405-eng-36. 13p.

The plasma propeller discussed in LAMS-2546 is given a nozzle, to improve its characteristics. The full nozzle design procedure is given, and the shape is calculated for a simple approximation to the behavior of the plasma thermocouples. (auth)

**32479** (MATT-127) THE FORCE FREE TOROIDAL ELECTROMAGNET WITH EXTERNAL FORCE-BEARING CURRENT LOOPS (thesis). Alfred Bahr (Princeton Univ., N. J. Plasma Physics Lab.). May 1962. Contract AT (30-1)-1236. 51p.

The force-free toroidal electromagnet is studied with respect to the question of whether or not the shape of the torus cross section can be controlled. The effect of various parameters on the shape and size of the torus is investigated. Some important mathematical relations for stationary fields are derived and a computer method based on those relations is described. Difficulties encountered in the computer test run are pointed out and some suggestions are given which might help to overcome those difficulties. (auth)

**32480** (ML-917) PLASMA SHEATH FORMATION BY RF FIELDS. H. S. Butler and G. S. Kino (Stanford Univ.,

Calif. Microwave Lab.). July 1962. Contract AF49 (638)-415. 31p. (AFOSR-2998)

It was observed experimentally that the application of a radio-frequency voltage (10 kc to 50 Mc) to any one of several electrode configurations around the outside of a plasma discharge tube results in a constriction of the luminous portion of the plasma away from the inner walls of the glass tube. Some observers identified this phenomenon with the r-f confinement mechanism as proposed by Weibel and by Boot, et al. However, an investigation established that the phenomenon is instead the result of an interaction between the externally applied r-f voltage and the plasma which leads to the formation of a d-c positive ion sheath. The physical mechanism by which the interaction occurs is basically one of rectification. It results from current flow from the plasma which can be represented as the resultant of two voltage-dependent current sources, one relating to the d-c probe characteristic of the plasma, the other to the physical movement of a body of electrons toward and away from the wall. There must be no average net current flowing from the plasma to the wall—an insulator. The interaction is described mathematically in terms of a differential equation. An approximation to this differential equation is derived whose solution is shown to fit qualitatively all the general characteristics of the phenomenon with regard to its dependence on arc current (or ion density) and on the frequency and amplitude of the applied r-f voltage. The differential equation in its most general form was solved numerically on a computer and the solution is shown to fit our experimental observations quantitatively for both square and sine wave inputs. An application of this phenomenon as a possible external diagnostic probe technique is proposed. (auth)

**32481** (NP-12054) ELECTRICAL POWER PROBLEMS IN FUSION RESEARCH. H. Hurwitz, Jr. (General Electric Co. Research Lab., Schenectady, N. Y.). Sept. 1958. 20p. (GP-96)

Although fusion power has not yet reached the stage of proven technical feasibility, it represents a challenging research opportunity for the electrical industry. After the primary goal of a self-sustained and controlled thermonuclear reaction has been achieved, there will remain the equally difficult task of progressing from laboratory demonstrations to practical and economical power plants. The electrical industry can contribute to the development of fusion power both by means of its own sponsored thermonuclear research programs and by furnishing special equipment and skills to the government program. The electrical approach to thermonuclear power which is based upon the ideas of magnetic containment and electrical heating is attractive. Several ingenious embodiments of this concept show considerable promise. It may, however, be necessary to obtain a more complete understanding of the properties of high-temperature plasmas before a self-sustained reaction can be achieved. A fundamental problem in fusion research is that of handling the large quantities of electrical energy needed in the experiments. Recent progress in the design of mechanical switches, capacitors, and ignitrons is discussed. Capacitor banks being used for fusion experimentation at the General Electric Research Laboratory are also described. (auth)

**32482** (NP-12058) I. IONIZATION OF CESIUM AT SURFACES. II. THE ENERGY DISTRIBUTION FOR ELECTRONS IN A THERMIONIC DIODE PLASMA CANNOT BE TRULY MAXWELLIAN. Technical Report No. 405. W. B. Nottingham (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics). Aug. 17, 1962. 28p.

Indications from voltage-current curves of thermionic power converters suggest increased ionization at, or very near, Cs-coated surfaces by low-energy electrons. Experiments were conducted to study this phenomenon quantitatively for a low Cs concentration. The tube contained three indirectly heated Ta surfaces surrounded by a shield. These heated surfaces, E1, E2, and E3, were Ta tubes located at the three corners of an equilateral triangle. The extension of a line from the corner E1 perpendicular to the base of the triangle formed by the line E2 and E3 served to locate the position of a fine-wire ion collector. Electrons were accelerated from surfaces E2 and E3 to bombard E1. Ions produced at or near E1 were then accelerated toward the ion collector to serve as a measure of the ion production. Results of this experiment indicate that no appreciable ion current was produced in Cs vapor controlled by a $T_{Cs} = 350°K$, by electrons having an energy less than 3.89 volts. The square root of the ion-to-electron current ratio was a linear function of the surface electron energy in excess of the ionization potential. Although not accurately determined, the ionization coefficient is given by $P_i = P_1(V-V_1)$ with $P_1 = 20\ cm^{-1}\ v^{-1}$ for the standard condition of $3.54 \times 10^{16}$ atoms/cm$^3$. For the refractory emitters, such as W, Ta, and Mo, operated in an energy-conversion diode, the ratio of the emitter temperature to the Cs temperature strongly affects the operating properties. If this ratio exceeds 3.2, an ion-rich sheath usually forms at the emitter surface. Electrons are accelerated in the plasma space by this injection potential. An analysis made here shows that at the open-circuit condition, the energy distribution of the electrons at the plasma edge of the emitter sheath cannot be a true Maxwellian over the entire range in electron energy. Instead, it is thought to be made up of two quasi-Maxwellians. The low-energy electrons are trapped and may have a high average energy close to that of the injection potential. The untrapped electrons will have an electron temperature equal to that of the emitter and their density will be that associated with an apparent or fictitious density many times that of the actual density. A theory was developed to describe quantitatively the relations that must be satisfied for the description above to apply. From typical numerical results that are applicable to specific diode configurations it is concluded that if the emitter-to-Cs temperature ratio exceeds 3.6, volume ionization is not required for a stable sheath. In the range 3.2–3.6 surface ionization is usually insufficient, and it is necessary to have volume ionization to sustain the sheath. Further studies are required to establish the mechanism. It may be direct ionization by high-energy electrons, or ionization from excited states of the cesium atoms. (auth)

**32483** (NP-12067) STUDY OF METASTABLE EXCITED ATOMS IN DISINTEGRATING GASEOUS PLASMAS. Technical Report No. 3, July 1961–July 1962. G. F. Sauter and H. J. Oskam (Minnesota. Univ., Minneapolis). Contract Nonr-710(37). 44p.

The study of the change in the number density of metastable excited atoms during the disintegration period of a pulsed discharge is considered to be essential for the explanation of phenomena occurring during the afterglow period. A survey is given of various collision processes by which metastable atoms are produced and destroyed in a gaseous plasma. The diagnostic method used is discussed and the necessary equipment described. Preliminary studies carried out on disintegrating plasmas produced in He are presented. (auth)

**32484** (NYO-9193) THE BOUNDARY LAYER IN THE CONFINEMENT OF A ONE-DIMENSIONAL PLASMA. W. Paskievici and A. Sestero (New York Univ., New York.

Courant Inst. of Mathematical Sciences). July 15, 1962. Contract AT(30-1)-1480. 31p. (MF-31)

An attempt to confine a plasma composed of electrons and ions by static, one-component, electric, and magnetic fields is described. All quantities depend on one space coordinate only, and the particle acceleration vector has two components. The contained plasma is assumed to be at rest with no electric or magnetic fields present. For the major portion of the discussion, the electron and ion temperatures are assumed equal and no trapped particles are permitted. For both species of particles the Vlasov equation is used. A charge-neutral approximation is discussed together with the exact solution, and numerical results are presented. It is shown on one hand that under the given assumptions the boundary layer cannot be charge-neutral throughout, and on the other hand that even the exact solution does not correspond to a desirable confinement configuration, as it contains a runaway ion jet and large electric fields. Two simple cases are presented, one with unequal ion and electron temperatures, and the other with trapped particles, in which a containment situation is indeed obtained. (auth)

**32485** (ORNL-3315) THERMONUCLEAR DIVISION SEMIANNUAL PROGRESS REPORT FOR PERIOD ENDING APRIL 30, 1962. (Oak Ridge National Lab., Tenn.). Sept. 12, 1962. Contract W-7405-eng-26. 105p.

Progress is reported on thermonuclear research. Separate abstracts were prepared for 8 of the 10 sections. Design and engineering service reports and notes are given in the remaining sections. (M.C.G.)

**32486** (ORNL-3315(p.1-14)) DCX-1 PLASMA EXPERIMENTS. J. L. Dunlap, R. S. Edwards, et al. (Oak Ridge National Lab., Tenn.).

Engineering modifications to the apparatus resulted in a lowest base pressure of $1.5 \times 10^{-9}$ torr; operating pressures down to about $2.5 \times 10^{-9}$ torr, with a pressure increment of less than $1 \times 10^{-10}$ torr/ma $H_2^+$; and trapped proton lifetimes as long as 37 sec. Neutral-particle-detector data indicate that at high pressures the plasma volume is 1 or 2 liters (corresponding to an average fast-proton density of about $10^7$ protons per cubic centimeter per milliampere of $H_2^+$) and that it is relatively independent of the $H_2^+$ beam current. At lower pressures, the initial volume is again about 1 or 2 liters, but expansion occurs in a few seconds during the buildup interval, and the equilibrium volume becomes quite sensitive to the $H_2^+$ current. With 8 ma of $H_2^+$ at $6 \times 10^{-9}$ torr, the equilibrium volume has expanded to the maximum of 10 liters permitted by the present structural configuration of the plasma chamber. At lower pressures wall collisions contribute to the steady-state proton loss rate. In addition to a slow component whose origin is obviously the charge-exchange loss of trapped energetic protons, the neutral-particle-detector signals also have a fast component which responds very rapidly to the $H_2^+$ beam and whose origin is not yet known. The decay time constants of the slow component of the signal are in accord with charge-exchange times, and the steady-state loss rates calculated by using only these charge-exchange signals are in excellent agreement with the calculated proton-trapping rates except under conditions of operation where the wall collisions play a role. Even under these conditions it appears that the plasma decays only by charge exchange once the $H_2^+$ beam is cut off. The specific forces driving the volume expansion are not yet clear, though it appears that they are collective rather than single-particle in origin. Other data have emphasized the increasing disorder of the plasma with increasing trapped-proton lifetime. Measurements of the energy distributions of escaping charge-exchange neutrals show broad energy spectra, with dependence on both pressure and injected $H_2^+$ current. As the pressure is lowered, the coherent rf signals from the circulating protons gradually become more discontinuous, the frequency bands wider, and the modulation patterns more noise-like than periodic. Ion-beam probe measurements of the plasma potential show that the lower pressures and larger $H_2^+$ beam currents produce both the higher potentials (up to 2 kv) and the larger ranges of fluctuation (hundreds of volts). (auth)

**32487** (ORNL-3315(p.15-20)) DCX-2. P. R. Bell, J. S. Culver, et al. (Oak Ridge National Lab., Tenn.).

The initial operation of DCX-2 is reported, particularly with regard to the ion cyclotron frequencies and their harmonics as seen when the $H_2^+$ beam is injected into the trapping volume at a pressure of about $10^{-6}$ torr. (auth)

**32488** (ORNL-3315(p.21-44)) PLASMA PHYSICS. M. C. Becker, R. A. Dandl, et al. (Oak Ridge National Lab., Tenn.).

The plasma produced by electron cyclotron resonance in a mirror geometry (Physics Test Facility) exhibited a magnetic structure, the study of which is described. The $\Delta B$ (diamagnetic) vs Z curve shows a positive $\Delta B$ of 9 gauss in the midplane on the axis and a normal negative $\Delta B$ of $4\frac{1}{2}$ gauss, $5\frac{1}{2}$ in. from the midplane. Construction of plasma shape via calculated equivalent current loops is being attempted. The experiment is undergoing changes for application of higher power at shorter wavelengths. More and quieter microwave power will permit exploration of density limits vs power and wavelengths and will allow study of the semicorrelated high-energy x-ray bursts. A thermal, neutral feed beam is also being attached so that specific radiofrequency heating zones (remote from walls) may be fed with gas. The 13-cm microwave heating system was applied in a preliminary way to the folded-cusp magnetic geometry (Elmo), and significantly favorable containment information was obtained. However, the measure of containment time is made by observation of the decay of microwave noise after interruption of the heating source, and in order to infer favorable containment at this time some rather weak assumptions are required, pending other measurements of temperature and density. Techniques for measuring the ion density, electron temperature, and rate of loss of a plasma are described. An application of these diagnostic techniques to plasmas of up to $10^{13}$ ions/cm$^3$ with electron temperatures of approximately 20 ev is also described. Gas damping of ionic sound waves is analyzed quantitatively. A conductor in close proximity to the turbulent plasma formed at the intersection of an electron stream and a neutral gas jet reduced the turbulence and increased the density of the plasma (presumably by "tying down" the magnetic flux lines). The plasma sweeper technique was applied to plasma contained in the simple cusp magnetic geometry. The plasma was stable and quiescent and had a maximum density when an additional folding field was applied. (auth)

**32489** (ORNL-3315(p.45-58)) VACUUM ARC RESEARCH. J. R. McNally, Jr., J. E. Francis, et al. (Oak Ridge National Lab., Tenn.).

At present, dissociation in DCX-1 is effected on the background neutral gas which is primarily hydrogen at about $4 \times 10^8$ particles per cubic centimeter. Utilization of an arc to enhance dissociation would be desirable if the arc can satisfy the following characteristics: have an ion species such that charge exchange to the trapped current is negligible, be able to operate in a low-pressure system

is order to maintain the low operating pressure of DCX-1, and achieve an ion density of about 50 times background. The arc developed in this work is a hydrogen-gas arc. A vacuum system was constructed which achieved a base pressure of $2.5 \times 10^{-10}$ mm Hg in the inner liner region while at liquid-nitrogen temperatures. An arc density of about $10^{10}$ ions per cubic centimeter can be achieved with a gas flow of 2 cc/min. At this flow, the pressure in the inner liner rises to $3 \times 10^{-9}$ mm Hg. The ion-to-neutral ratio under these conditions is about 30 to 1. (auth)

**32490** (ORNL-3315(p.59-63)) ION PRODUCTION, ACCELERATION, AND INJECTION. R. C. Davis, R. R. Hall, et al. (Oak Ridge National Lab., Tenn.).

The 600-kv injector was removed from its test stand and installed on DCX-2, where it is operating satisfactorily. A tube was built in order to continue the study of high-intensity beams and their production. Equipment was developed in order to study the angular and spatial distribution of current in these beams. Components testing of the accelerator was satisfactorily completed. Failure of the center coil (around the ion source) delayed further testing of the effect of electron injection. Future experimentation with the accelerator will be carried out on a vacuum test stand. Extensive testing of the hollow-cathode arc discharge as an ion source is being initiated. A 300-ma beam of unanalyzed hydrogen was obtained at a 16-kev accelerating voltage. A high-voltage shielding arrangement was constructed and should allow the accelerating voltage to be increased to about 35 kev. A neutral beam source consisting of two coaxially mounted hollow-cathode arc discharges is being constructed. One discharge will serve as an ion source; the accelerated ions will be confined magnetically to move longitudinally through the second or converter arc. Dissociation of molecular ions in the converter arc should be the primary source of neutrals. Optimization of neutral production will be accomplished by variation of the type of converter arc and variation of the dissociation path of the molecular-ion beam in the converter arc. Neutral-beam collimation should be very good because of the confining magnetic field and converter arc geometry. (auth)

**32491** (ORNL-3315(p.64-71)) THEORY AND COMPUTATION. T. K. Fowler, Mozelle Rankin, et al. (Oak Ridge National Lab., Tenn.).

Topics on theory and computation discussed are as follows: ion density vs injection current in DCX-2, in which it is shown that refined calculations with charge exchange and ionization cross sections properly averaged over ion and electron energy distributions do not markedly increase previous estimates of upper critical current; secondary plasma phenomena; three new features of a minimum principle for stability; potential distribution calculations for DXC-1; and calculation of electron trajectories in the folded double cusp, "Elmo." (auth)

**32492** (ORNL-3315(p.72-8)) MAGNETICS. C. E. Parker, J. E. Simpkins, et al. (Oak Ridge National Lab., Tenn.).

Families of normalized curves are presented which allow the rapid calculation of magnet coils. Optimum coil parameters are obtained. In addition the method also gives the field variations when the coil parameters are changed. Examples for both conventional and superconducting coils are shown. The design of a new magnet system is described. This two-coil, vertical-axis system will have variable coil separation and will produce a nominal field of 80 kilogauss. This facility will be used initially to perform carefully planned engineering tests for providing additional coil-design data and to ultimately produce relatively large-volume homogeneous fields for research in superconductivity. A method for building solenoids from flexible cables was developed which under certain conditions provides magnet coils more quickly and cheaply than possible in the conventional way. The results of computer studies on the loop-replacement approximate method of calculating axial forces for rotationally symmetrical coil pairs are reported. A systematic application of the resulting computer codes for multicoil systems is presented, with illustrations from Long Solenoid reversed-field studies. (auth)

**32493** (ORNL-3315(p.79-84)) VACUUM SYSTEMS, TECHNIQUES, AND MATERIAL STUDIES. R. E. Clausing, J. D. Redman, et al. (Oak Ridge National Lab., Tenn.).

Metal-film pumping, vacuum instrumentation, diffusion pumps, and material studies in development of vacuum systems and techniques are discussed. (M.C.G.)

**32494** (ORO-556) A THEORETICAL INVESTIGATION OF THE DIFFUSION OF A CHARGED PARTICLE IN A PLASMA UNDER THE INFLUENCE OF A SINUSOIDALLY OSCILLATING EXTERNAL MAGNETIC FIELD. Plasma Physics Bulletin Vol. 4. Martin E. Shucart (Miami, Fla. Univ., Coral Gables). 1962. Contracts AF19(604)-8082 and AT(40-1)-2761. 24p.

It is shown that by proper consideration of the mechanisms which affect a charged particle in a gas, a distribution function may be derived for use in the calculation of the displacement of this particle. It is also shown that under special magnetic field conditions, a result in complete agreement with the Einsteinian theory will be found. These results depend, in part, on the dynamical friction coefficients of the gas. A high-frequency approximation for finding a correction to the diffusion due to the sinusoidal magnetic field is presented. (M.C.G.)

**32495** (TID-3557(Suppl.1)) CONTROLLED FUSION AND PLASMA RESEARCH. A Literature Search. Sidney F. Lanier, comp. (Division of Technical Information Extension, AEC). Aug. 1962. 201p.

A total of 1672 references are included concerning plasma physics, magnetohydrodynamics, magnetic confinement, experimental devices, and other subjects related to controlled fusion research. The references were taken from Nuclear Science Abstracts (NSA) for the period Jan. 1961 through May 1962. The information presented supplements that in the literature search which appears as TID-3557 and the bibliography which appears as TID-3072 (Rev.1). (J.R.D.)

**32496** (USCEC-83-215) SELF-SIMILAR AND PSEUDOSIMILAR SOLUTIONS OF BLAST WAVES IN ELECTROGASDYNAMICS. Koichi Oshima (University of Southern California, Los Angeles. Engineering Center). Aug. 1962. Contract AF 49(638)-831. 37p.

A series of solutions of blast waves accompanied by charge separation are investigated. Using the electrogasdynamical equations and the Poisson equation, a characteristic length, $R_e$, which is proportional to the Debye length divided by a ionization rate of a gas, is defined. This length plays an important role in the electrogasdynamical blast wave. Since the classical gasdynamical blast wave with a constant energy contained in it has a characteristic length, $R_0$, which is defined by the constant energy, the essential parameters of the electrogasdynamical blast wave with a constant energy in it are $R_0$ and $R_e$, or the square of its ratio, $A_e$. A self-similar solution of the electrogasdynamical blast wave is found. Its shock front propagates exponentially with time and its energy also increases exponentially with time. Several numerical calculations with various values of the parameter, $R_e$, were carried out. This solu-

tion contains a classical gasdynamical blast wave as a limiting case of $R_s \to \infty$. Under reasonable assumptions, a pseudosimilar solution of the electrogasdynamical blast wave is introduced, which has a constant energy throughout its propagation. After numerical calculations, the propagation and decay of this blast wave are determined for several values of the parameter $A_0$. In a limiting case of $A_0 = 0$, this solution agrees with the classical similar solution for the strong blast wave. Although all the numerical calculations are carried out only for the case of one-dimensional blast wave in a gas with a value of $\gamma = 5/3$, characteristics of the electrogasdynamical blast wave are such that under the effect of the electrostatic field of the charged particles, the blast wave is weakened. For values of $A_0$ smaller than 1, the effect of this is not significant, but for values of $A_0$ larger than 1, its effect becomes serious. (auth)

**32497** INITIAL VALUE SOLUTION OF MAXWELL'S EQUATIONS IN COLD PLASMA. Richard A. Gerwin (Boeing Scientific Research Labs., Seattle). Am. J. Phys., 30: 711-15(Oct. 1962).

The calculation is presented for the case of a cold, collisionless, uniform electron plasma. (auth)

**32498** FLOATING MULTIPLE PROBE SYSTEMS FOR PLASMA MEASUREMENTS. K. M. Burrows (Univ. of New South Wales, Kensington, Australia). Australian J. Phys., 15: 162-8(June 1962).

A new analysis of the current voltage characteristic of a floating double probe system is given, showing that the electron temperature must be estimated from measurements at the point of inflection of the characteristic if positive ion movement contributes to the probe circuit current. Temperature measurements will still be in error if the rates of variation of positive ion current to the two probes are not closely similar as the potential difference between them is varied. An alternative experimental technique is described which will yield correct temperature estimates in such circumstances, and is simpler and less perturbing to the plasma than the floating triple probe method. (auth)

**32499** PLASMA PINCH COMPRESSION BY LONGITUDINAL MAGNETIC FIELD WITH SHOCK WAVE. V. S. Tkalich. Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk, Mekham. i Mashinostr., No. 3, 11-14(May-June 1962). (In Russian)

Studies were made of a theta-pinch plasma column with axial magnetic field compressed by an increasing external longitudinal magnetic field. The plasma is formed by a traveling shock wave. The analysis is confined to the compression of the plasma layer formed by a shock wave in a non-conducting gas. (R.V.J.)

**32500** EQUILIBRIUM MECHANISM IN A P.I.G. REFLEX DISCHARGE AND EXPERIMENTAL DETERMINATION OF $D_\perp$ IN A PLASMA. R. Geller and D. Pigache (Centre d'Etude Nucléaires, Saclay, France). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research, 4: 229-42(Aug. 1962). (In French)

A preionized-gas reflex discharge is studied experimentally and theoretically with static field $B_0 < 400$ gauss. The density of the plasma varying between $10^{12}$ to $10^{14}$ particles/cm$^3$, either a weakly or strongly ionized gas can be studied. After having established the conditions of equilibrium of the discharge, a method of measuring the coefficient of perpendicular diffusion is devised, and experimental results are compared with theoretical predictions. (auth)

**32501** STUDY OF THE TRANSMISSION OF A PLASMA JET THROUGH A MAGNETIC BARRIER. A. Bariaud, M. Korman, P. Lecoustey, J. Lelegard, H. Luc, and J. Tachon (Association Euratom-CEA, Fontenay-aux-Roses, France). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research, 4: 243-52(Aug. 1962). (In French)

The ion temperature of a plasma jet is deduced by measuring the transmission of plasma through a magnetic barrier. The experimental results are evaluated by using a theoretical model. The plasma, which is produced by a hydrogenated titanium washer gun, shoots into a straight vessel of 15 cm diameter and 2 m length. It propagates parallel to a magnetic field with a speed varying between 1 and $4 \times 10^7$ cm/sec. The magnetic guiding field at the gun and detection locations can be varied from 0 to 1000 gauss. The maximum amplitude of the magnetic barrier field, placed at the mid-plane of the vessel, may reach 14,000 gauss. For a 1000-gauss guiding field, the observed ion temperature of the hydrogen jet is found to be $40 \pm 10$ ev. (auth)

**32502** THE INFLUENCE OF ERRORS ON PLASMA-CONFINING MAGNETIC FIELDS. D. W. Kerst (General Atomic Div., General Dynamics Corp., San Diego, Calif.). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research, 4: 253-62(Aug. 1962). (GA-2925) (In English)

Endless lines of force confined in toroidal plasma-containing geometries are subject to periodic perturbations by field errors, which can produce integral, half-integral, third-integral, quarter-integral, etc. resonant-like disturbances on the spiraling line of force. A formal analogy exists between the topology of a trace of a line of force in the co-ordinate space of a plasma-confining region and the trace of a phase point in the phase space for a particle orbit in an accelerator. The methods used for determining stability limits for particles in periodic accelerators are thus applicable to the problem of confining lines of force in stellarators and pinches. Examples are given and computer methods are described for typical stellarator configurations subject to a variety of field errors. (auth)

**32503** EXPERIMENTS CONCERNING THE MAGNETIC CONFINEMENT OF A COLD PLASMA. I. Alexeff, R. V. Neidigh, and E. D. Shipley (Oak Ridge National Lab., Tenn.). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research, 4: 263-6(Aug. 1962). (In English)

A steady-state plasma in a magnetic field is generated by an electron stream along magnetic field lines that pass through a neutral gas jet. Plasma turbulence is observed by a technique that removes the plasma ions without greatly disturbing their density distribution. In general, the amplitude of the turbulence is found to increase with the magnetic field strength. The magnetic field required for onset of turbulence increases with increasing ion mass. Transport of plasma across the magnetic field rises with the turbulence. A mirror magnetic field produces more turbulence than a uniform magnetic field, and a cusp magnetic field produces no turbulence in the plasma. (auth)

**32504** COMPARISON BETWEEN THEORETICAL AND EXPERIMENTAL RESONANT BEHAVIOUR OF A HOLLOW CYLINDRICAL PLASMA. A. M. Messiaen and P. E. Vandenplas (Ecole Royale Militaire, Brussels). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research, 4: 267-70(Aug. 1962). (In English)

Theory using an equivalent permittivity approach predicts that a hollow cylindrical plasma column should have two resonance frequencies. Two hollow cylindrical discharge

tubes of different sizes are built with great care and enable the observation of two well-defined resonance peaks. Agreement is found between theory and experiments for both the frequencies and the amplitudes. A comparison with the ordinary cylindrical plasma column is made. (auth)

**32505** STABILITY CRITERION FOR LONGITUDINAL PLASMA WAVES IN A MAGNETIC FIELD. Y. Ozawa (Hokkaido Univ., Sapporo), I. Kaji, and M. Kito. J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research, 4: 271-85(Aug. 1962). (In English)

The dispersion equation of Cauchy integral type for longitudinal plasma oscillations in a magnetic field is derived exactly, in order to obtain the general instability criterion for magnetoplasma oscillations, on the basis of the Vlasov collision-free kinetic equation for arbitrary velocity distributions. The motion of the ions is taken into account. Terms important for the drift instability can be written. Two terms correspond to the dispersion relation either for the case of strong magnetic field approximation or for the case of grazing angle propagation. A third term contributes to the drift instability in the case of wave propagation at an appreciable angle to a finite magnetic field. Fourth and higher order terms give rise to the instability arising from anisotropic velocity distributions. The criterion for plasma instability in a magnetic field is obtained using potential theory. The character of the sign distribution of a particular function determines whether or not unstable plasma oscillations occur. The correspondence of the various possible sign combinations to stability or instability is tabulated. This criterion is applied to a particular anisotropic velocity distribution function. The unstable regions are determined for variation of parameters, magnetic field intensity, anisotropy, and angle between wave vector and magnetic field vector. (auth)

**32506** THE EFFECT OF THE INTERACTION OF IONS ON THEIR EQUILIBRIUM CONCENTRATION. S. G. Brush (Univ. of California, Livermore). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research, 4: 287-9(Aug. 1962). (In English)

The hypothesis is studied that the electrostatic interaction of ions in an ionized gas tends to favor ionization and at that sufficiently high pressures the degree of ionization begins to increase with pressure. By using some improvements of the Debye-Hückel theory, it is shown that, while in a particular case this effect does not occur at any pressure for which the theory is valid, it does occur at somewhat lower temperatures. Thus a type of 'pressure ionization' is obtained from a classical model without invoking volume-dependence of energy levels or similar effects. (auth)

**32507** HEATING OF A HEAVY CHARGE IN AN ELECTRON PLASMA. A. Gaylitis (Inst. of Physics, Academy of Sciences, Latviyskaya SSR). Latvijas PSR Zinatnu Akad. Vestis, No. 2(175), 83-7(1962).

The heating of a particle of mass M with a charge e, which is introduced into an electron plasma of temperature T, was studied. Heating of the particle is understood to mean the reaching of the mean kinetic energy of electrons by collisions with it. $M \gg m$, where m is the electron mass. At the instant $T = 0$, the particle is in the origin of coordinates. The amount of energy the particle receives per unit time from the electrons which are in the radius $R \ll n^{-1/3}$, where n is the electron density, was calculated. Outside R, an electron moves rectilinearly, and inside R, in a potential field. (OTS)

**32508** COULOMB INTERACTION IN A PLASMA IN A UNIFORM MAGNETIC FIELD. Kazuo Kitao (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 27: 1069-71(May 1962). (In English)

A formulation of the Coulomb interaction in a plasma in a uniform magnetic field is presented that takes into account anisotropies in the particle temperatures resulting from the presence of the magnetic field. (T.F.H.)

**32509** IMPURITY EFFECTS ON THE PLASMA OSCILLATION OF AN ELECTRON GAS. Y. H. Ohtsuki (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 27: 1082-3(May 1962). (In English)

The one-particle Green's function for a system of degenerate non-interacting electrons is used to calculate the longitudinal dielectric constant of the electron system. The imaginary part of the dielectric constant is used to determine the dispersive term of the damping factor, which factor governs the plasma oscillations in the electron system. (T.F.H.)

**32510** CAUCHY'S PROBLEM FOR A KINETIC EQUATION OF PLASMA. S. V. Iordanskii. Trudy Mat. Inst. im. V. A. Steklova, 60: 181-94(1961).

The boundary value problem: $\partial n/\partial t + v\partial n/\partial x - (e/m)E(x,t)\partial n/\partial v = 0$, $\partial E/\partial x = -4\pi e(\int_{-\infty}^{\infty} n(v,x,t)dv - n_0)$, and $n_{t=0} = f(x,v) > 0$, $\lim E_{x\to\infty} = 0$ is considered. If the continuous function $f(x,v) > 0$ fulfills the conditions, the following principal result is obtained: $\int_{-\infty}^{\infty} |\int_{-\infty}^{\infty} f(x,v)dv - n_0| dx = 0$, $f(x,v) < K(v)$, $\int_{-\infty}^{\infty} v^2K(v)dv < \infty$, where K(v) is a monotonically decreasing function of $|v|$, then the problem will be unambiguously solvable. Finally, the results are generalized for the case of a plasma with more than one component. (OTS)

**32511** TURBULENT HEATING OF A PLASMA. M. V. Babykin, P. P. Gavrin, E. K. Zavoiskii, L. I. Rudakov, and V. A. Skoryupin. Zhur. Eksptl'. i Teoret. Fiz., 43: 411-21(Aug. 1962). (In Russian)

Results of investigations of anomalous absorption of large amplitude electromagnetic waves in a plasma are presented. The energy absorption observed is connected with excitation of small scale instabilities by the electron current. It was previously shown that a large amplitude electromagnetic wave moving across a magnetic field experiences strong attenuation which cannot be explained by collision losses. Some new experiments are described which confirm the role of collective motions in the dissipation of the energy of a wave in a plasma. The electron temperature is determined, the dependence of the absorption on the angle between the magnetic field and the direction of propagation of the wave is elucidated, and the possibility of collisionless ion heating is discussed. Since this type of plasma heating is connected with the development of small scale instabilities, the term "turbulent" heating is proposed to designate this method of heating. (auth)

**32512** ON THE INITIAL STAGE OF DEVELOPMENT OF DISTURBANCES IN A PLASMA LOCATED IN AN EXTERNAL MAGNETIC FIELD. F. M. Nekrasov. Zhur. Eksptl'. i Teoret. Fiz., 43: 483-9(Aug. 1962). (In Russian)

Longitudinal and transverse oscillations in a magnetized plasma moving along an external constant magnetic field are considered on basis of linear kinetic theory. The oscillations are induced by weak disturbances of the plasma distribution function. The problem is reduced to an integral equation and thus the initial conditions can be taken into account. It is demonstrated that in the initial stage of development of a certain type of disturbance the space Fourier components of the electromagnetic field may increase. The growth conditions and its character are determined. (auth)

**32513** NONLINEAR THEORY OF ATTENUATION OF PLASMA WAVES. V. E. Zakharov and V. I. Karpman. Zhur. Eksptl'. i Teoret. Fiz., 43: 490-9(Aug. 1962). (In Russian)

Absorption of monochromatic plasma waves of finite (but small) amplitude in a rarefied plasma is considered. The nonlinear distortion of the electron distribution function under the action of the wave is derived. The damping decrement is calculated and found to depend on the wave amplitude $\Phi_0$ as $\Phi_0^4$. (auth)

**32514** CONVECTION INSTABILITY AND THE STABILIZATION EFFECT IN A RAREFIED HIGH TEMPERATURE PLASMA. A. B. Mikhailovskii. Zhur. Eksptl'. i Teoret. Fiz., 43: 509-17(Aug. 1962). (In Russian)

It is shown that in a low density plasma in which the Debye radius is small compared to the ion Larmor radius, the convective instability stabilization effect mentioned by Rosenbluth, Krall and Rostocker, vanishes. Stability of a plasma with respect to disturbances involving an arbitrary ratio of the Larmor radius to wave length is investigated under various assumptions regarding the initial ion velocity distribution function. (auth)

**32515** HIGH FREQUENCY CONDUCTIVITY OF A PLASMA IN THE PRESENCE OF A DIRECT CURRENT. M. E. Gertsenshtein and V. I. Pustovoit (Lebedev Inst. of Physics, Moscow). Zhur. Eksptl'. i Teoret. Fiz., 43: 536-42(Aug. 1962). (In Russian)

It is shown that the conductivity of a plasma for a longitudinal wave in the presence of carrier drift may be negative in the low frequency region. The appearance of negative conductivity is connected with the movement of the space charge. Although only the plasma analogue of the problem is considered, the results obtained can also be applied to gas carriers in semiconductors and semiconducting piezocrystals. The kinetic equation is solved by Enscog's method. Exact formulas are obtained which are convenient for numerical calculations and reduce to simple expressions in the low frequency range. (auth)

**32516** THE STRUCTURE OF WEAK SHOCK WAVES IN A PLASMA. R. V. Doich (Deutsch) (Moscow State Univ.). Zhur. Eksptl'. i Teoret. Fiz., 43: 667-76(Aug. 1962). (In Russian)

The structure of weak shock waves in anisotropic magnetohydrodynamics is investigated. An expression is given for the width of weak shock waves for any direction of the shock wave front with respect to the magnetic field direction. This general expression is considered in detail for a completely ionized plasma. The dependence of the velocity of weak shock waves on pressure discontinuity is presented as well as the relation between the magnetic field strength, hydrodynamic velocity and pressure discontinuities. Finally an expression is given for the attenuation coefficient of weak magnetosound waves in anisotropic magnetohydrodynamics. (auth)

**32517** MAGNETOHYDRODYNAMICS. OTS Selective Bibliography, August 1960 to January 1962. (Office of Technical Services, Washington, D. C.). 11p. (SB-426 (Suppl.1)). $0.10(OTS).

A bibliography of reports listed in the semi-monthly abstract journals U. S. Government Research Reports and Technical Translations is presented. About 185 entries are included. (J.R.D.)

# Shielding

*Refer also to abstracts 32567 and 32604.*

**32518** (AEEW-R-163) RESONANCE SHIELDING IN THORIUM–GRAPHITE MIXTURES. L. I. Tirén (Organization for Economic Co-Operation and Development, Paris) and J. M. Jenkins (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Establishment, Winfrith, Dorset, England). Mar. 1962. 43p.

Resonance absorption by thorium contained in graphite-thorium compacts was studied over a range of C : Th atomic ratios from 10 to 2000, by means of an activation technique. The resonance self-shielding factors obtained were correlated in terms of the equivalent scattering cross section per absorbing atom. A comparison was made with other available data on thorium resonance absorption. (auth)

**32519** (NAA-SR-7432) SNAP SHIELD TEST EXPERIMENT FISSION-PLATE POWER CALIBRATION. R. L. Tomlinson (Atomics International. Div. of North American Aviation Inc., Canoga Park, Calif.). Aug. 15, 1962. Contract AT(11-1)-Gen-8. 36p.

Three techniques were employed in measuring the fission rate of the STE (SNAP Shield Test Experiment) fission source plate; the thermal neutron absorption rate, power dissipation (calorimetric method), and the fission-neutron production technique. The results obtained, when weighted according to the reciprocal of the squares of the estimated errors, yielded a fission rate of $1.97 \times 10^{12}$ fissions/sec ±4% for a STE reactor power level of 50 kw. Assuming that 190 Mev of usable energy is liberated per fission of $U^{235}$, this fission rate corresponds to a fission-plate power of 59.9 watts ±4%. The calorimetric calibration technique proved to be the most satisfactory of the three techniques used. The design of the STE fission source plate allowed the plate to be enclosed completely in fiberglass insulation and heated electrically as well as by nuclear means. The heating rate is sufficiently high that errors caused by ambient temperature changes are negligible. Details of the three calibration techniques employed are given. The average fission-plate power per unit area was determined to be $2.05 \times 10^{-2}$ watts/cm$^2$ ±4%, or about 14 times that of the Oak Ridge National Laboratory (ORNL) Lid Tank Facility fission plate. Although this is one-sixth that of the design value (apparently due to graphite contamination), it is satisfactory for the initial shield measurements of the SNAP Reactor Development Program. The possibility of raising the power of the fission plate at least a factor of 5 through modification of the bismuth window and graphite thermal column is being investigated. In addition, the reactor power is capable of an increase from 50 to 500 kw for short-period operation by minor changes in the external piping and replacement of the primary coolant pump. Extended operation of 500 kw would necessitate the addition of a larger heat exchanger. Ultimately, however, the STE reactor fission plate is limited to a power of about 500 watts without supplementary radiation shielding. (auth)

**32520** (XDC-60-2-28) NEUTRON AND PHOTON TRANSPORT THROUGH SHIELDING MATERIALS. T. D. Roberts (General Electric Co. Aircraft Nuclear Propulsion Dept., Cincinnati). Oct. 15, 1959. Contract AT(11-1)-171. 16p.

Experimental data describing neutron and gamma attenuation through shielding materials were used to determine the validity of four solutions of the Boltzmann transport equation. A well-known solution utilizing diffusion theory

has stronger limitations than solutions utilizing transport theory, based upon the Sn method. Some of the limitations are discussed. The more general Sn method is capable of treating neutron and photon transport, anisotropic neutron scattering, photoneutron production, absolute fluxes, and other phenomena not previously so susceptible to analysis. The moments method is shown to be applicable, with certain limitations, to high energy neutrons. Correlations of experimental foil activities with predictions made by various IBM-704 programs are made. (auth)

## Theoretical Physics

**32521** (62-RL-3075E) PERTURBATION THEORY OF CLASSICAL SYSTEMS WITH TIME-DEPENDENT FORCES. S. Tamor (General Electric Co. Research Lab., Schenectady, N. Y.). Aug. 1962. 34p.

The problem of finding the motion of a Hamiltonian system in which the forces depend explicitly upon the time is solved by means of time-dependent perturbation theory. The final motion is expressed in terms of the initial conditions by means of a scattering operator whose perturbative expansion is shown to converge. If at the initial and final times the Hamiltonian is time independent and varies slowly in the interim, the change in the action variables is found to be an infinitely flat function of a slowness parameter in every order of perturbation theory, thus demonstrating explicitly the adiabatic invariance of the action integral "to all orders." This result shows the connection between time-dependent perturbation theory and the WKB approximation. Separate treatments are given for the linear system and the general Hamiltonian system. The former is susceptible to a comparatively simple algebraic treatment which exhibits more clearly the essentials of the problem. Two examples are given to illustrate the method. (auth)

**32522** (UCRL-10432) A SHELL MODEL THEORY OF THE R-MATRIX. W. Tobocman (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 1962. Contract W-7405-eng-48. 12p.

A method for dealing with the nuclear many-body problem is suggested. The approach is a refinement of the shell model in which the asymptotic boundary conditions are used as constraints in a variational calculation of the R-matrix. Since it is the R-matrix that is calculated, this method should provide a description of nuclear reactions and decays as well as of nuclear bound states. (auth)

**32523** POWER-SERIES SOLUTIONS FOR ENERGY EIGENVALUES. Don Secrest, K. Cashion, and Joseph O. Hirschfelder (Univ. of Wisconsin, Madison). J. Chem. Phys., 37: 830-5(Aug. 15, 1962).

A numerical method is presented for rapidly calculating the energy eigenvalues of one-dimensional Schrödinger equations. It is applicable to systems for which the potential is either analytic or has no pole of order greater than two. The method is based on a power-series expansion of the wave function at large distances. With the use of high-speed computing machines the large number of terms required in the power series can be computed easily. The method is illustrated by obtaining energy eigenvalues for a number of one-dimensional systems with potentials of the type $V = kx^{2n}/2n$. It is also applicable to a variety of systems of physical interest. As an example, an exact energy eigenvalue for a rotating Morse oscillator was calculated. This is compared with that obtained from Pekeris' approximate analytical solution. (auth)

**32524** SPECIAL THEORY OF RELATIVITY. Herbert Dingle. Nature, 195: 985-6(Sept. 8, 1962).

An inconsistency in the kinematical part of Einstein's special theory of relativity is pointed out which has far-reaching consequences in nuclear physics. The inconsistency lies in the fact that the argument used to prove that moving clocks run slow, proves with equal validity that moving clocks run fast. The passage from Einstein's original paper giving the argument is quoted together with a parallel passage which gives the opposite conclusion. Refutation or criticism of this article is requested. (D.L.C.)

**32525** INTERPRETATION OF QUANTUM PHYSICS. T. E. Phipps (Naval Ordnance Test Station, China Lake, Calif.). Nature, 195: 1088-9(Sept. 15, 1962).

The exchange of views of Stopes-Roe and Lande on questions of interpretation in quantum physics is reviewed briefly. Other questions concern objectivity, and a different approach to interpretational problems and paradoxes is given which attacks the mathematical formalism directly. In this approach, the "event" and concept and objectivity are restored. The difficulties remaining are discussed. An answer by Stopes-Roe is included. (D.L.C.)

**32526** GENERALIZED SINGULAR FUNCTIONS IN LOWER LORENTZ SPACES. Irja Nieminen (Univ. of Lund, Sweden). Nuclear Phys., 37: 250-71(Aug. 1962). (In English)

The generalized singular functions in m-dimensional Lorentz space are calculated for m = 2 and 3. A similar set of functions is also calculated for the same values of m. These functions are given for positive as well as for negative values of the mass variables, whenever they exist. The second type of function is also calculated for 4-dimensional Lorentz space for a special case. The results obtained for positive values of the mass variables are similar to those obtained for 4-dimensional Lorentz space. (auth)

**32527** ON A TRANSFORMATION OF CAYLEY GENERALIZED TO TRANSFORMATIONS OF FOLDY-WOUTHUYSEN AND CINI-TOUSCHEK. M. Baktavatsalou (Institut Henri Poincaré, Paris). Nuovo cimento (10), 25: 964-72(Sept. 1, 1962). (In French)

An attempt is made to unify the Foldy-Wouthyusen and Cini-Touschek transformations into one Cayley's transformation. The transformed operators in the Cayley representation are listed. It is shown that the Eriksen transformation can be deduced from that of Cayley. (auth)

**32528** A METHOD OF COMPUTING PHASE SHIFTS AND NORMALIZATIONS OF CONTINUUM-STATE DIRAC WAVE FUNCTIONS. I. Hauser and R. J. Malhiot (Illinois Inst. of Tech., Chicago). Nuovo cimento (10), 25: 1061-71 (Sept. 1, 1962). (In English)

A method is proposed for computing the phase shifts and normalizations of the spherical wave functions of an unbound Dirac electron in the electric field of a point or finite-sized nucleus. The method uses the phase-amplitude forms $G(r) = A\cos\varphi$ and $F(r) = A\sin\varphi$ for the radial factors. The first step is to compute $\varphi(r_1)$, where $r_1$ is larger than the nuclear radius but is still reasonable for machine computations in many cases of interest. This first step requires a numerical solution of radial differential equations from $r = 0$ to $r = r_1$. The second step is to compute the phase shift and a normalization correction factor directly from an asymptotic series, whose n-th term is of the form $P(\varphi)r_1^{-n}$, where $P(\varphi)$ is a finite Fourier series in $\varphi(r_1)$. Formulas for upper bounds on the error in the series are given and are used to estimate suitable values of $r_1$ for

several cases. The series is especially suitable for problems like the decay of a $\mu$-mesic atom, where the wave functions must be computed in any case up to distances $\gtrsim r_1$. (auth)

**32529** POSTULATIONAL APPROACH TO SCHWARZSCHILD'S EXTERIOR SOLUTION WITH APPLICATION TO A CLASS OF INTERIOR SOLUTIONS. F. R. Tangherlini (Duke Univ., Durham, N. C.). Nuovo cimento (10), 25: 1081-1105(Sept. 1, 1962). (In English)

In order to clarify the physical ideas underlying Schwarzschild's exterior solution, a postulational derivation is given that does not make use of the field equations. Basically this amounts to replacing two field equations by two postulates, one of which is a strong version of the principle of equivalence, and the other, of Newton's inverse square law. These postulates are more general than the approach would indicate, and there is actually a class of solutions for static systems with spherical symmetry which satisfy them. The energy-stress tensors producing these solutions have the important property that energy density equals radial stress. Two examples of interior solutions that fulfill these postulates are given: a solid sphere and a hollow shell. The basic properties of these solutions are described and compared with those of Schwarzschild's interior solution. The solid sphere solution is used to complete a previous discussion of the clock paradox. The field equations for static systems with spherical symmetry are written in a form that indicates the limitations of the postulates. (auth)

**32530** A SIMPLIFIED QUANTUM ELECTRODYNAMICS. P. Rastall (Univ. of British Columbia, Vancouver). Nuovo cimento (10), 25: 1183-9(Sept. 1, 1962). (In English)

A version of quantum electrodynamics is presented in which the Heisenberg-picture field equations and commutation relations are exactly the same as in the conventional theory, but in which an indefinite metric is not used, and no subsidiary condition needs to be imposed on the state vectors. The equivalence of this theory to the conventional one is shown by subjecting the Heisenberg-picture equations to a gauge transformation and then going over to the interaction picture. (auth)

# REACTOR TECHNOLOGY

## General and Miscellaneous

*Refer also to abstract 31801.*

**32531** (AAEC/E-90) THE MICROBIOLOGY OF HEAVY WATER IN THE HIFAR REACTOR. P. S. Davis and G. G. McPherson (Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). June 1962. 11p.

The high flux research HIFAR contains ten tons of heavy water which acts as moderator and primary coolant. Over an eighteen months period regular microbiological examinations were carried out on samples of heavy water taken from various parts of the circuit. The heavy water circuit provides an interesting opportunity for the study of microorganisms because of the high isotopic purity (greater than 99.6 per cent), and the high chemical purity of the heavy water in the reactor. Furthermore, during its passage through the reactor core the water and suspended bacteria are subjected to intense irradiation, the neutron flux being approximately $10^{14}$ neutrons $cm^{-2}$ $sec^{-1}$. The presence of bacteria in the heavy water circuit has been demonstrated. Experimental results and methods used are discussed. Some evidence is presented to show that the ion-exchange resin bed contributes nutrients to support bacterial growth. (auth)

**32532** (AEEW-M-217) MONTE CARLO EVIDENCE ON THE RESONANCE INTEGRAL AND DOPPLER COEFFICIENT OF CALDER HALL REACTORS. J. E. Beardwood (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Establishment, Winfrith, Dorset, England). Apr. 1962. 14p.

The available Monte Carlo evidence on the resonance integral of $U^{238}$ in Calder Hall reactors was assessed and compared with experiments and theory. It was observed that the Monte Carlo estimates are somewhat larger than any others. This was explained by comparison with theory since the latter assumes a 1/E flux and the Monte Carlo work shows that approximately 0.8 barn is added to the resonance integral due to the non-1/E nature of the flux at energies greater than 50 kev. (auth)

**32533** (AEEW-R-182) STAGNANT — A ONE-DIMENSIONAL, STEADY-STATE, TWO-GROUP, FORTRAN PROGRAMME FOR STEAM-GENERATING P.T.Rs. D. Moxon (United Kingdom Atomic Energy Authority. Reactor Group. Atomic Energy Establishment, Winfrith, Dorset, England). July 1962. 22p.

A one-dimensional, steady-state program is presented for solving the two-group neutron diffusion equations simultaneously with the heat transfer, hydraulic, and poison equations. It can be used to estimate the axial variation of neutron flux, coolant density, fuel temperature and xenon concentration along a boiling channel of a pressure-tube reactor. Criticality search is on either control poison in the moderator or moderator height. (auth)

**32534** (DANATOM-06-61) FEM KONTROLSTANGS-DREV. EN BESKRIVELSE, ANALYSE OG KRITIK FORETAGET AF KONTROLSTANGSGRUPPEN. (Five Control Rod Drives. A Summary, Analysis and Critique Prepared by the Control Rod Group). (Danish Assn. for Industrial Development of Atomic Energy, Hellerup). Dec. 1961. 88p.

The Control Rod Group of Danatom made a study and comparison of the control rod drives of five reactors—Yankee, Dresden, Savannah, Shippingport, and Alpha. (J.S.R.)

**32535** (EURAEC-311) FISSION GAS RELEASE FROM URANIUM DIOXIDE. Quarterly Progress Report No. 5, January 1, 1962 to March 31, 1962. (FIAT. Sezione Energia Nucleare, Turin). Apr. 30, 1962. Work Performed under United States—Euratom Joint Research and Development Program. Contract 021-60-9-RDI. 20p. (FN-E-22)

A fission gas apparatus was assembled in a 10-cm Pb cell, and operation was started with full-sized pellets in accordance with the experiment statistical design. Three Mallinckrodt samples irradiated at low burnups were tested with the standard post-irradiation annealing technique which includes drilling the sample container under vacuum, diffusion anneal for 6 hrs, and fusion in potassium pyrosulfate. Values obtained for the apparent diffusion coefficient are included. Preparation and selection of Mallinckrodt, C.E.A., and C.N.E.N. natural $UO_2$ samples is reported and data on their characteristics are included. Open porosity curves of these powders are included. Open and closed porosity curves as a function of density and open porosity distribution for 5 different densities near the nominal values of the statistical design of the experiments are also reported for these powders. (J.R.D.)

**32536** (EURAEC-333) STATISTICAL METHODS FOR HOT CHANNEL AND HOT SPOT CALCULATION. Quarterly Progress Report No. 5, January 1, 1962 to March 31, 1962. (FIAT. Sezione Energia Nucleare, Turin). Apr. 30, 1962. Work performed under United States—Euratom Joint Research and Development Program. Contract 035-60-11-RDI. 33p. (FN-E-20)

Codification of the SHOC code on the IBM-7090 was completed. Comparison between results obtained with the statistical "spot" model and the current conservative method involving the maximum allowable deviations was initiated. Data obtained by inspection of the Yankee Critical Experiment fuel rods on material variation characteristics were used for input. These data are standard deviations and mean values of pellet radius, internal and external cladding radius, fraction of theoretical density, and atomic % enrichment. Preliminary results indicate a strong reduction of the correction factor relative to enthalpy rise, in comparison with the value obtained by considering the maximum allowable deviations for the entire channel. A general dependence for the correction factor on the channel neutron flux distribution was also found. Results of a study concerning a typical hot channel correction factor relative to the enthalpy ($F^{\Delta H}$) rise are included. (J.R.D.)

**32537** (GEAP-3956) MARITIME LOOP IRRADIATION PROGRAM. SAVANNAH I FUEL IRRADIATION. Quarterly Progress Report, January 1, 1962—March 31, 1962. D. W. Danielson and R. S. Gilbert (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.). Apr. 30, 1962. Contract AT(04-3)-189. 19p.

The S-I-5-B-M fuel irradiation in the GETR Maritime Loop is described. Data are summarized in tabular form. Fuel performance, fuel environment, and loop operations are discussed. (M.C.G.)

**32538** (GEAP-4053-1) ACCURATE NUCLEAR FUEL BURNUP ANALYSES. First Quarterly Report, December 1961—February 1962. B. F. Rider (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). Apr. 1, 1962. Contract AT(04-3)-189. 16p.

Activities in a program to develop mass spectrometric techniques for use in reactor fuel burnup analysis are reported. The program emphasis is on measurement of nonradioactive refractory fission products that can be related to burnup. A controlled irradiation program is being initiated to prepare foils of $U^{235}$, $Pu^{239}$, and $U^{233}$ for use in development of stable fission product methods and measurement of the relative fission yield of these isotopes. Isotopic dilution tracers, chosen on the basis of low occurrence in fission, are being procured. Work on evaluation of radiation hazards in the mass spectrometric laboratory is progressing. In work on the mass spectrometry of stable isotopes, Nd sensitivities of 50 to 100 μg were found to be required for the vibrating reed detector, but 1 nanogram sensitivity can be obtained on the electron multiplier detector. Data are included on fission-product radioisotopes, apparent fission yield, and specific activities. (J.R.D.)

**32539** (HW-73915) RESEARCH AND DEVELOPMENT PROGRAMS EXECUTED FOR THE DIVISION OF REACTOR DEVELOPMENT. Quarterly Progress Report, January–March 1962. S. Goldsmith and P. F. Ashbrook, eds. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Aug. 1, 1962. Contract AT(45-1)-1350. 246p.

Research and development progress is reported on plutonium fuels, ceramic uranium fuels, physics, chemical research and development, analytical studies and advanced concepts, materials development and corrosion studies, irradiation effects on materials, gas-cooled reactor studies, instrumentation and nondestructive testing; and Plutonium Recycle Test Reactor operation and related activities. (M.C.G.)

**32540** (HW-SA-2119) OPTIMUM USE OF SUBGROUPING CERTAIN 100% INSPECTION SITUATIONS. J. L. Jaech (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Mar. 7, 1961. Contract AT(45-1)-1350. 10p.

The use of a pooling technique in leak testing Plutonium Recycle Test Reactor fuel elements to reduce the number of tests is discussed. Since the proportion of defectives in this case is small, application of the method would suggest that the group size be large. It was suggested that additional savings might be introduced by subgrouping the originally grouped items in the event of a positive result, rather than testing them individually. An investigation was made to determine optimum subgrouping sizes. (M.C.G.)

**32541** (NAA-SR-Memo-7570) INVESTIGATION OF THE STRESS AND DEFLECTION BEHAVIOR OF SLOTTED GRAPHITE MODERATOR LOGS. M. M. Lemcoe and A. L. Sherwood (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). July 16, 1962. Contract [AT-11-1-GEN-8]. 9p.

On the basis of a room temperature study of nine different slot configurations, it is believed that the 30 in., eight slot (per end) log configuration should perform the best under service conditions. At room temperature, this configuration provides a factor of safety of 6.7 against cracking failure. At 1200°F, this factor of safety would be approximately 15% higher because of the increased strength properties at elevated temperatures. None of the logs tested had failure pressures approaching those at which buckling of the process tube would result. Log cracking, rather than process tube buckling, therefore, constitutes the critical mode of failure for the process tube-graphite log combination. (auth)

**32542** (NP-12082) OECD HIGH TEMPERATURE REACTOR PROJECT DRAGON THIRD ANNUAL REPORT, APRIL 1, 1961–MARCH 31, 1962. (European Nuclear Energy Agency, Paris). 196p.

The technical predictions on which the work was originally based were confirmed at this point in development, and no significant changes in the basic concept have been necessary. Progress on construction of the reactor building and installation of the pressure vessel are reported. Research and development are reported on reactor safety, reactor theory, reactor physics, heat transfer, and gas dynamics, component development, coolant processing, graphite, and fuel elements. Descriptions of graphite assemblies and control engineering and instrumentation are also included. (J.R.D.)

**32543** (ORNL-TM-353) DISCUSSION OF AN ACTIVATION METHOD FOR MEASURING THE RATIO OF $U^{238}$ ABSORPTION TO $U^{235}$ FISSION IN A REACTOR. C. A. Preskitt (Oak Ridge National Lab., Tenn.). Aug. 10, 1962. Contract [W-7405-eng-26]. 24p.

The theory is presented in detail of an activation method for measuring the ratio of $U^{238}$ absorptions to $U^{235}$ fissions in a nuclear reactor. The origin of the activities is discussed, the equations are given for interpretation of the measurements, and the expected counting rates are computed for a typical experiment in the EGCR. (auth)

**32544** (ORNL-TM-354) USE OF THE DRY MAINTENANCE FACILITY FOR HRT MAINTENANCE. J. Paul Jarvis (Oak Ridge National Lab., Tenn.). Sept. 17, 1962. Contract [W-7405-eng-26]. 7p.

A portable shield was utilized in performing nine semi-direct dry maintenance jobs on the HRT. The shield proved to be completely reliable, affording a considerable savings in maintenance costs and reactor downtime. (auth)

**32545** (SGAE-62/2B) EXPERIMENTELLE ÜBERPRUFUNG DES REAKTORMODELLS. (Experimental Verification of Reactor Models). H. Schmidl (Österreichische Studiengesellschaft für Atomenergie, G.m.b.H., Vienna). 1962. 34p.

The theoretical model of a boiling water reactor is compared with experimental results and an improvement of the model was attempted. The correction need not be of a formalistic nature but must give the possibility of supplementing the basic physical equations or of improving the parameters. It is shown that the usual methods are not sufficient. Additional methods were developed, including distribution of the block diagram into individual sub-regions, calculation of correction functions for these regions which show the difference between theoretical model and experimental result, and decomposition of the measured ranges of frequency into several sections, and step-wise approximation of the correction function against zero. The reactor dynamics are considered from three points of view: the theoretical side, experimental testing of dynamic reactor behavior, and analysis of experimental results with comparison with the theoretical values. The theoretical analysis and the comparison with the theoretical model are based on the Halden Reactor Experiment. (J.S.R.)

**32546** TID-16581) TWO DIMENSIONAL THERMAL SPECTRUM CALCULATIONS. J. W. Smiley, J. J. Bulmer, and J. P. Shannon (Knolls Atomic Power Lab., Schenectady, N. Y.). [1962]. Contract [W-31-109-eng-52]. 6p.

A two dimensional thermal spectrum program, AMOK, is discussed along with some preliminary analytical and experimental results obtained with the computer program. The AMOK program gives peak power density results consistent with present techniques and in a direction such as to improve the calculational results with experimental results. The fairly good agreement between AMOK and the

MND scheme in predicting power peaks suggests the continued use of the MND scheme for parametric studies. The computer time currently observed for AMOK problems versus MND problems is nearly three to one. Hence, AMOK is expected to be used primarily for final design calculations. (N.W.R.)

**32547** (TID-16681) CRITICAL STUDIES WITH ZPR-III FOR THE ENRICO FERMI FAST REACTOR CORE B. T. A. Doyle and A. L. Hess (Argonne National Lab., Idaho Falls, Idaho). June 1962. Contract [W-31-109-eng-38]. 13p. (UAC-6527)

Experiments in the Zero Power Reactor with a mockup of the second core loading, Core B, of the Fermi Fast Reactor are described. These experiments were conducted to provide basic critical data for the Core B reactor. Measurements were made on the reaction rates and fission ratios, and information was obtained concerning reactivity effects of various radial-reflectors. (J.R.D.)

**32548** (TID-16762) ASYMPTOTIC AND TRANSIENT ANALYSIS OF PULSED MODERATORS. P. B. Daitch and D. B. Ebeoglu (Rensselaer Polytechnic Inst., Troy, N. Y.). [1962]. Contract [AT(30-1)-1995]. 23p.

The time dependence of neutron transport in moderating assemblies is investigated. Analytic solutions are found for pulsed sources in finite and infinite media using low order approximations. The wave front and other transients are clearly distinguished from the asymptotic solution. The work is extended to arbitrary P-L approximations for an arbitrary number of energy groups. Transients are classified and conditions for the existence of an asymptotic state are clarified. (auth)

**32549** (UNC-5034) A REVIEW OF ANALYTICAL AND EXPERIMENTAL WORK PERTINENT TO THE DOPPLER EFFECT IN FAST REACTORS. Charles C. Graves (United Nuclear Corp. Development Div., White Plains, N. Y.). Aug. 31, 1962. Contract AT(30-1)-2832. 58p.

An evaluation of the state-of-the-art on the Doppler effect in fast reactors is presented. A review concerning calculation methods is included and recommendations for further work in these areas are given. Procedures are emphasized for treating various portions of the resonance region when cross-section data such as average widths and spacings are given. (J.R.D.)

**32550** NUCLEAR REACTOR SAFETY SYSTEMS. M. W. Jervis. AEI (Assoc. Elec. Ind.) Eng., 2: 222-8 (Sept.-Oct. 1962).

A nuclear reactor safety system is designed to provide an automatic safeguard for the reactor under fault conditions. It is also important that the safety system does not generate faults of its own. The basic layout of a safety system is described, and it is shown that application of the principles of coincidence and redundancy to the circuits can provide the necessary combination of extreme reliability and freedom from spurious operation. The safety system of the Berkeley power station is described. Some of the current developments in safety circuit are discussed. (D.L.C.)

**32551** ANALOG SIMULATOR FOR THE STUDY OF NUCLEAR PLANTS. Giancamillo Ambrosini, Sergio Barabaschi, and Line Gentilini (Comitato Nazionale per de Ricerche Nucleari, Rome). Automazione e Strumentazione, 6: 251-61(1960). (CNI-75). (In Italian)

A general description is given of the reactor simulator of the C.N.R.N. at Ispra. The nuclear structure, the control system, thermal structure, production plant, reference voltage, control and command circuits, and the registration channels are discussed. In an appendix the components of the delay circuits and the integrator are considered. (J.S.R.)

**32552** THE CALCULATION OF REMOVAL CROSS SECTIONS BETWEEN OVERLAPPING THERMAL GROUPS. D. C. Leslie (Atomic Energy Establishment, Winfrith, Dorchester, Eng.). J. Nuclear Energy, Pts. A & B. Reactor Sci. and Technol., 16: 303-10(June 1962). (AEEW-R-133)

The use of two overlapping thermal groups has been recommended by a number of authors for the study of problems such as the variation of thermal spectra across lattice cells and flux peaking in water gaps. The Kottwitz problem (two semi-infinite media at different temperatures, with neither sources nor absorption present) is used as an example, and three different methods for calculating the removal cross sections between the groups are presented. Numerical values for the removal cross sections are quoted using the free gas model of thermalization. If the diffusion coefficient of a medium is independent of energy, its removal cross sections are found to be independent of temperature. The work requires extending to situations with finite absorption, and more sophisticated models of thermalization should be used. (auth)

**32553** A KINETIC SIMULATOR FOR NUCLEAR REACTORS IN THE LIGHT OF RECENT ANALOG METHODS. Gian Paolo Caligiuri. Riv. Ing., 11: 3-11(Nov. 1961). (In Italian)

The theoretical bases of reactors are briefly reviewed as an introduction to a discussion of reactor simulators. The design of the basic simulator circuit is shown and various types of kinetic simulator circuits are described. (J.S.R.)

**32554** A NUCLEAR KINETICS PROBLEM SOLVED USING AN ANALOG MACHINE. Gian Paolo Caligiuri. Riv. Ing., [12]: 1-4(Jan. 1962). (In Italian)

An analog computer solution of the decrease of reactor power with time is shown. The scaling of the equations and the analog simulator network is described. (J.S.R.)

**32555** NEW ANALOG EXPERIMENTAL METHOD FOR THREE-DIMENSIONAL SIMULATION OF NUCLEAR REACTORS. Gian Paolo Caligiuri and Hervé D'Hoop (Comitato Nazionale per l'Energia Nucleare, Ispra, Italy). Riv. Ing., No. 5, 2-16(May 1962). (In Italian)

An analog experimental method using at the same time the eigenfunctions and the finite difference for the tridimensional representations of nuclear reactors is described. The variable coupling was realized by means of conversion matrices, materialized in the analog computer either with the general effect of voltage and amplification division or with function generators. The mathematical model used in the simulation is described. Then the equations for the neutron flux, temperature, and reactivity are derived. The experimental results are shown graphically. Appendices show the derivation of a general solution for the flux equation, eigenfunctions and eigenvalues of the Lapacian, calculations of the matrix M, and calculations of the modal reactivity. (J.S.R.)

**32556** REACTIVITY MEASUREMENTS OF NATURAL $UO_2$–HEAVY WATER LATTICES IN PLATR. G. E. Foster, W. L. Brooks, and H. Sooeak (United Nuclear Corp., White Plains, N. Y.). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 18p. $0.50.

The Pawling Lattice Test Rig was used to evaluate the infinite multiplication factor and the thermal neutron utilization for heavy-water-moderated lattices. The principle of void substitution was employed to determine lattice modification needed to make $k_\infty = 1$. The magnitude of three

systematic errors generally introduced into such $k_\infty$ measurements was determined experimentally to be: improper neutron spectrum = 0.001 max.; heterogeneity effects due to the presence of Al and other structural materials within the test region = 0.008 max.; the fundamental heterogeneity correction which relates the void cell to the fueled cell = 0.004 for the 37-rod $UO_2$ cluster which was the largest cluster studied. Tables of results and experimental parameters are given. (A.G.W.)

**32557** PROCESS FOR THE CONTROL OF NUCLEAR REACTORS. (to United Kingdom Atomic Energy Authority). French Patent 1,244,853. Sept. 19, 1960.

A reactor consisting of fuel element assemblies immersed in a liquid coolant is described. The control of the reactivity consists in placing these assemblies horizontally so that the assemblies may be dispersed for decreasing the reactivity. Preferably each assembly has the shape of a plate, a series of parallelly disposed assemblies forming the core. The assemblies are displaced in directions parallel to the assembly front faces, in a manner that adjacent assemblies move in opposite directions, and a decrease of the overlapping of the assemblies results in a decrease of reactivity and vice versa. Each assembly is supported via sloping surfaces which slide on guides in the core support structure so that the assemblies under the influence of their own weight tend to move in such a way that a dispersion of the core occurs. Other means are provided for moving the assemblies in directions resulting in a concentration of the core and for keeping them in the desired predetermined relative positions. (NPO)

**32558** IMPROVEMENTS RELATING TO NUCLEAR FUEL ELEMENTS. (to Babcock and Wilcox Co.). French Patent 1,251,894. Dec. 12, 1960.

A fuel element assembly consisting of a plurality of parallel fuel rods distributed over a square cross section is described. These fuel rods are supported and enclosed by an elongated casing provided at its extremities with a circular entrance and an exit nozzle. One of these nozzles is removable for facilitating the rechange of the fuel rods. The circular part of the nozzle is constituted by a hollow socket which is introduced into an axial boring of an intermediate piece having an outer surface which fits in the end of the casing having an essentially square cross-section. This piece is fixed in the casing by screws. The socket is provided with screws serving as pins of a bayonet coupling engaging in corresponding grooves in the wall of the boring. A funnel shaped transition piece is provided with a tubular end portion engaging in the socket and is pressed by a spring with its wide-mouthed extremity against the fuel rod in order to form a connection between the nozzle and the space occupied by the fuel rods. (NPO)

**32559** ADJUSTABLE COOLANT FLOW RESTRICTOR IN A NUCLEAR REACTOR. (to United Kingdom Atomic Energy Authority). French Patent 1,254,203. Jan. 9, 1961.

It is desirable to operate a reactor with a constant coolant exit temperature. This involves individual control of coolant flow in the fuel element channels. A reactor with an adjustable coolant flow restrictor, the setting of which is under the control of temperature-sensitive means whereby a change of temperature of the coolant in the channel causes variation of the flow to stabilize the temperature of the outflowing coolant is described. The temperature-sensitive means may comprise an assembly of members having thermal expansion characteristics such that changes in coolant temperature result in a change in the dimensions of the assembly. Preferably this assembly of members comprises alternately arranged ceramic rings and dished metallic washers whereby a change in coolant temperature results in a change in the degree of dishing of the metallic washers, thereby resulting in a change in assembly length. (NPO)

**32560** IMPROVEMENTS RELATING TO THE COOLING OF NUCLEAR REACTORS. (to Société Rateau). French Patent 1,254,435. Jan. 16, 1961.

In graphite moderated reactors, the graphite structure may be changed by radiation, this change is generally known as Wigner effect. In order to eliminate this inconvenience, a cooling system is provided, so that in the moderator or the other materials of the structure a temperature distribution is effected only by an adequate arrangement of the circulation of the cooling fluid without burdening of the thermodynamic balance of the installation. Preferably two kinds of reactor channels are provided. In the channels of the first kind the coolant circulates in a certain direction while in the channels of the second kind it circulates in the opposite direction. For each of the channels of the first kind there are adjacent channels of the second kind so that for each kind of channel their centers form a lattice covering the whole reactor cross section. Preferably the exit header for the cooling of one kind of channels is placed inside the entrance header of the other kind of channels so that among the headers only the entrance headers are in contact with the biological shield, thus preventing the heating of this shield by the hot coolant. The effect of these measures with respect to elimination of the Wigner effect is an average moderator temperature essentially constant in the direction along the reactor channels. (NPO)

**32561** SCRAM DEVICE FOR NUCLEAR REACTORS. (to United Kingdom Atomic Energy Authority). French Patent 1,263,561. May 2, 1961.

The scram device comprises releasable means for restraining a multiplicity of discrete bodies or including magnetic material from passage along a tube. Preferably the releasable means comprise an electromagnet of partly annular pole pieces of opposite polarity, the pole pieces forming between them a passage for the bodies in the tube. This electromagnet forms a magnetic field which passes through some or all of the bodies and serves to restrain them against movement along the passage between the pole pieces. The de-energization of the magnet serves to release the bodies and the fall by gravity into the core to shut down the chain reaction. Preferably the magnetic means also include discrete portions of material having a Curie point which is exceeded should the reactor achieve a temperature in excess of a maximum safe temperature whereby discharge of the bodies occurs. (NPO)

**32562** NUCLEAR REACTOR. (to United Kingdom Atomic Energy Authority). French Patent 1,264,202. May 8, 1961.

A reactor consisting of a spherical pressure vessel and a core structure of generally cylindrical shape with a D-section annulus connecting to the pressure vessel is described. Coolant flow ducts extend radially from apertures in the pressure vessel in the region of the annulus and a shield is provided between the apertures and core structure so that the ducts are only exposed to tolerable activation when the reactor is operating and to tolerable gamma radiation when the reactor is shut-down. (NPO)

**32563** IMPROVEMENTS RELATING TO NUCLEAR REACTORS. (to A.E.I.-John Thompson Nuclear Energy Co., Ltd.). French Patent 1,264,283. May 8, 1961.

Emergency devices are known wherein liquid neutron absorbent material is located above the reactor core and under conditions of emergency is allowed to fall into a duct

in the core. Improved means are provided for resetting the equipment after a trip. These means comprise a plunger in the duct and normally resting at the bottom of the duct. The plunger, which in this position supports the neutron absorbent material after a trip, is connected to a rod, cable, or the like whereby after a trip the plunger may be lifted so as to lift the neutron absorbent material to make it flow over the edge of the upper open extremity of the duct in order to let it fall into an annular space forming a container from which the material may be released again in the case of an emergency. (NPO)

**32564** TESTING DEVICE FOR RESEARCH IN THE DYNAMIC BEHAVIOUR OF NUCLEAR REACTORS ESPECIALLY OF BOILING WATER REACTORS. (to Licentia Patent-Verwaltungs-G.m.b.H.). French Patent 1,265,462. May 23, 1961.

In order to predict the behavior of boiling reactors, a test loop is provided for simulating the thermodynamic conditions. An electrically heated body simulating the fuel element is enclosed by a container filled with water serving as both coolant and moderator. The developed steam-water mixture is led to a steam separator, the separated water being reinduced into the container. Instruments are provided, using x-ray diffusion, for measuring the average density of the steam-water mixture. An electric signal representing this density is compared with a standard signal, the difference signal being fed into a reactor simulator, which evaluates the power of the real reactor to be simulated. This power signal serves after an appropriate amplification to control the heating of the simulated fuel element. (NPO)

**32565** AUTOMATIC SCRAM DEVICE OF A NUCLEAR REACTOR IN WHICH A COOLANT FLOWS. (to Société Escher Wyss). French Patent 1,267,367. June 12, 1961.

The automatic scram device comprises a container in the exit header of the reactor coolant and encloses a gaseous neutron absorber held at the temperature of the hot gas circulating in the exit header. This container communicates via ducts with normally closed nozzles in the entrance header of the coolant and are directed so that when the closure is broken the neutron absorbing gas flows directly with the cold coolant into the reactor channels to shut down the chain reaction. Preferably the closure of the nozzles is constituted by a diaphragm which bursts when the pressure in the container, caused by a forbidden temperature increase of the hot coolant, exceeds a predetermined value. (NPO)

**32566** NUCLEAR REACTOR WITH AN INTERSPACE PROVIDED BETWEEN THE THERMAL INSULATION AND THE BIOLOGICAL SHIELDING. (to Licentia Patent-Verwaltungs-G.m.b.H.). French Patent 1,270,229. July 17, 1961.

In most reactors an interspace is provided between the outer surface of the pressure vessel or a thermal insulation covering the outer surface and the biological shielding. Generally this interspace is kept at a pressure lower than the pressure in the regions of the reactor building frequented by the operators, so that gas activated by neutrons and escaped from the core cannot enter the frequented regions. The activity of the gas in this interspace induces an additional irradiation dose in the regions. In order to limit the additional dose, the boundary surface of the interspace is covered with a neutron absorbing layer. Preferably the top layer of the thermal insulation or the innermost layer of the biological shielding may be constituted by a strong neutron absorber. By these measures a great part of the thermal neutrons escaping the pressure vessel as well as the thermal neutrons created in the shielding by moderation are absorbed in these layers, so that the activation of the gas in the interspace is reduced. (NPO)

## Power Reactors

*Refer also to abstracts 31802 and 31819.*

**32567** (ACNP-62016) PATHFINDER ATOMIC POWER PLANT SHIELDING ANALYSIS. R. J. Holl and D. W. Stephen (Allis-Chalmers Mfg. Co. Atomic Energy Div., Milwaukee). July 15, 1962. For Northern States Power Co., Minneapolis and Central Utilities Atomic Power Associates. Contract AT(11-1)-589. 131p.

Shielding for the Pathfinder Atomic Power Plant, which incorporates a direct-cycle controlled-recirculation boiling-water reactor with an integral nuclear superheater, was designed. Information is presented on the shield design, dose levels for all areas of the plant, and methods of calculation. Major sources are the reactor complex in the reactor building, the main steam line, turbine, condenser, and feedwater system in the turbine building, and the waste disposal system and spent fuel in the fuel handling building. Biological shield for the reactor consists of concrete with earth fill on one side and 18 ft of shielding water over the reactor. The turbine foundation, condenser water box, the operating floor, and concrete walls serve as shielding for the unrestricted areas of the turbine building. A pool is provided for shielding spent fuel in the fuel handling building, with additional shielding provided for components of the waste disposal and reactor-water purification system. (auth)

**32568** (ACNP-62020) PATHFINDER ATOMIC POWER PLANT DETAILED FLUX MEASUREMENTS IN SUPERHEATER CELLS. H. F. Finn and R. H. Vollmer (Allis-Chalmers Mfg. Co. Atomic Energy Div., Milwaukee). Aug. 27, 1962. For Northern States Power Co., Minneapolis and Central Utilities Atomic Power Associates. Contract AT(11-1)-589. 37p.

Experiments were conducted in the Allis-Chalmers Critical Experimental Facility to determine the region-average thermal flux and flux shape in a unit Pathfinder superheater cell. Accurate values are necessary in order to calculate superheater constants. Measurements were made using Cu-Mn wires (radial traverse for region-average) and Al-U foils (sectioned for region-average) and foilettes (for flux detail). The radial traverse measurements using wire provided a first-order approximation of the region-average flux but was found inadequate because of a flux gradient across the test location chosen and because of the lack of sufficient detail. The measurements with foil and foilettes eliminate these inadequacies and provided credible measurements of both region-average thermal flux values and a detailed description of the flux shape in the unit superheater cell. Significant discrepancies existed between the experimental results and results of one-dimensional calculations using a cylindricized cell, as would be expected. The calculated value of the thermal flux in the moderator is too low. Two-dimensional cell diffusion calculations showed fair agreement with experimental results. The experimental results were used to compute flux-weighted thermal-group superheater constants used in two-group diffusion theory calculations of the superheater flooding coefficient. Results obtained were more consistent with experimental measurements of the flooding coefficient than those obtained using constants calculated from other assumed flux distributions. (auth)

**32569** (AGN-TM-374) ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM. EVALUATION OF A URANIUM–GLASS FUEL SYSTEM FOR THE GCRE. P. F. Young (Aerojet-General Nucleonics, San Ramon, Calif.). July 1962. Contract AT(10-1)-880. 46p.

Possible applications of glass as a fuel element diluent in the Gas-Cooled Reactor Experiment are discussed. Glass technology is summarized. Quantitative data on nuclear properties and radiation damage effects are presented. Investigations of uranium glass are reviewed. A uranium-glass fuel system for the GCRE is described. It is concluded that the $UO_2$-glass fuel system may offer important advantages over present systems. Further investigation is required for quantitative evaluation of these advantages. (auth)

**32570** (AMF-388-TR-1) COMPONENT FEASIBILITY TEST REPORT FOR THE AMF ON-POWER REFUELING SYSTEM FOR THE DOUGLAS POINT PLANT. (AMF Atomics, Div. of American Machine and Foundry Co., Greenwich, Conn.). Feb. 1962. Contract AT(38-1)-233. 155p.

Activities in a phase of CANDU I refueling machine development are reported which are concerned with obtaining test data for various system subcomponent parts. The basis for selecting those units requiring test was established through engineering evaluation of available information. Results of tests based on these requirements are included in the form of test reports. (J.R.D.)

**32571** (APAE-112(Vol.III)) 30 MEGAWATT HEAT EXCHANGER AND STEAM GENERATOR FOR SODIUM COOLED REACTOR SYSTEM. VOLUME III. MATERIAL AND WELDING SPECIFICATIONS. (Alco Products, Inc., Schenectady, N. Y.). June 29, 1962. Contract AT(11-1)-666. 58p.

Material inspection and welding specifications are presented for various parts of both the intermediate heat exchanger and steam generator. Tables are included that indicate the applicable parts and assemblies to which these specifications apply. For other parts, where the material requirements are not severe, the ASTM or other indicated specifications are applicable. (J.R.D.)

**32572** (GAMD-3032) EXPERIMENTAL MEASUREMENTS ON A PARTIAL HTGR CORE MOCKUP. J. R. Brown and M. K. Drake (General Atomic Div. General Dynamics Corp., San Diego, Calif.). June 25, 1962. Contract AT(04-3)-314. 53p.

The nuclear design of the Peach Bottom HTGR core involved development of calculation techniques and input data for the specification of the core loading. Although some of the input data were derived from experiments with the lattice critical assembly, it was desirable to test the calculation methods and input data on a relatively clean assembly having characteristics similar to those of the HTGR core. The experimental program was planned to calculate overall $k_{eff}$ and the accuracy of calculations of the reactivity coefficients of the various core materials. Experiments were also included to check the effectiveness of control rod groups and the over-all temperature coefficient at temperatures up to 300°C. (J.R.D.)

**32573** (GEAP-3877) NUCLEAR SUPERHEAT PROJECT NINTH QUARTERLY PROGRESS REPORT, JULY–SEPTEMBER 1961. R. T. Pennington (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Contract AT(04-3)-189. 202p.

Engineering physics studies were performed which reveal that significant improvements in axial fuel clad temperature profiles may be obtained by the use of axial variations in enrichment and burnable poisons. Materials development is being emphasized after chloride stress crack failures in stainless steel fuel elements. A topical report concerning the experimental and analytical phases of the AEC Superheat Critical Program is being written. In coolant testing, metallographic examinations of 304 stainless steel specimens exposed isothermically for 4500 hr in 1050°F steam were made. Low metal-to-system losses were measured; however, the possibility of metal-to-system loss rate increase with longer exposure was indicated. In heat transfer experiments, three crackdown runs with Reynolds numbers up to 880,000 were completed during the period. In SADE development, irradiations were performed on two 0.028-in. stainless steel clad annular fuel elements. Fabrication was started on the SH-5 fuel element with 0.016-in.-thick cladding. Design work continued on the E-SADE and Mass Spectrum Superheat Reactor. (J.R.D.)

**32574** (HW-SA-2749) EXPERIENCE WITH THE PLUTONIUM RECYCLE TEST REACTOR. R. I. Smith and R. E. Peterson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Sept. 1962. Contract AT(45-1)-1350. 16p.

A description of the Plutonium Recycle Test Reactor is presented along with a discussion of the first years operating experience. It was found that substantial quantities of Pu can be used in thermal reactors along with natural U under power conditions without creating any undesirable or unsafe control characteristics. (J.R.D.)

**32575** (IDO-19021(Vols.I&II)) ABWR — PL-2 DESIGN REPORT, OCTOBER 15, 1960. (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.). Contracts AT(10-1)-967 and DA-44-192-ENG-11. (CEND-103(Vols.I&II)). 624p.

These two volumes were issued separately, but are cataloged as a unit.

The PL-2 is a natural circulation, boiling water reactor plant designed to deliver 1000 kw of net electric power and 1,365,000 Btu/hr net thermal power for space heating. The plant is similar in design to the SL-1 which was operated at NRTS since 1958. Details are given concerning installation of PL-2 in a snow tunnel; however, this reactor is suitable for installation on permafrost and conventional underburdens. Modular construction is employed to minimize field erection. All modules can be air-transported and are suitable for surface transport. Data are included concerning the plant and descriptions are given concerning the plant and reactor. A compilation of specifications for major plant components is included. (J.R.D.)

**32576** (IDO-28590) ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM. Semiannual Progress Report, January 1 through June 30, 1962. (Aerojet-General Nucleonics, San Ramon, Calif.). Aug. 17, 1962. Contract AT(10-1)-880. 218p.

Highlights of the work performed in connection with the Army Gas-Cooled Reactor Systems Program for the period January through June 1962 are discussed. The program includes the Gas-Cooled Reactor Experiment; the ML-1, a prototype mobile gas-cooled nuclear power plant; the ML-1A; and an advanced systems project. The purpose of the program is to develop a mobile nuclear power plant suitable for military field use (the ML-1A). A core test facility was operated at the AEC's NRTS (the GCRE) to provide information for use in designing and developing the ML-1, a prototype power plant, now being tested at NRTS. Background information on the Gas Turbine Test Facility is included. Progress on these projects is reported with information on associated tests and data evalu-

ation, and the status of experimental and prototype components. (auth)

**32577** (LA-2746) FAST REACTOR ROCKET ENGINES—HEAT TRANSFER. Ralph S. Cooper (Los Alamos Scientific Lab., N. Mex.). June 1962. Contract W-7405-eng-36. 51p.

Analytical approximations and detailed numerical calculations were used to investigate heat transfer in $H_2$-cooled fast reactors suitable for rocket engine application. The maximum power density and exit gas temperatures were determined as functions of the reactor design parameters and material properties. Fluid flow and heat transfer in the gas allow flow rates of the order of 1 lb/sec/in.$^2$ of cross-sectional flow area corresponding to 2000 Mw per ft$^2$ of flow area. Thermal stress in the fuel elements may limit the power density and flow rate to lower values but adequate theory and data are lacking to define this quantitatively. (auth)

**32578** (MITNE-24) RECALCULATION OF POWER COSTS FOR THE CANDU REACTOR. C.-F. G. Hsi and M. Benedict (Massachusetts Inst. of Tech., Cambridge). Sept. 15, 1962. Contract AT(30-1)-2073. 17p. (NYO-9716)

Results of computation are presented concerning the CANDU Reactor power costs. Lower values are used for the prices of $UO_2$, fabrication, and enriched $UF_6$ than those used in the previously published report NYO-9715. (J.R.D.)

**32579** (MND-MD-2560-5) PM RESEARCH AND DEVELOPMENT PROGRAM. Fifth Quarterly Progress Report, April 1, 1962–June 30, 1962. (Martin Co. Nuclear Div., Baltimore). Contract AT(30-1)-2706. 176p.

Research and development work on the PM reactor program is reported under the following topics: core design development, fuel element and core component development, irradiation testing, critical experiments and zero power testing, and heat transfer tests. (M.C.G.)

**32580** (NASA-TN-D-1407) REACTOR-WEIGHT STUDY OF BERYLLIUM OXIDE, BERYLLIUM, LITHIUM-7 HYDRIDE, AND WATER AS MODERATORS WITH TUNGSTEN 184 STRUCTURAL MATERIAL AND URANIUM DIOXIDE FUEL. Robert E. Hyland (National Aeronautics and Space Administration. Lewis Research Center, Cleveland). Sept. 1962. 41p.

Consistent basic P1 equations, which include terms for elastic and inelastic scattering, are used to compute some unreflected homogeneous reactors. Reactor weights are obtained as functions of void fractions. Minimum weights for the reactors as functions of cross-sectional void area are obtained by variation of reactor dimensions and use of consistent amounts of fuel ($UO_2$) and tungsten as functions of void area. The reactors are then compared on this minimum-weight basis. The $H_2O$ moderated reactors were the lightest. Variations in fuel applied to them indicate possible savings in fuel loadings with little change in reactor weight. (auth)

**32581** (NP-12038) FACT SHEETS ON U. S. NUCLEAR POWER PROJECTS. Fourth Edition. (Bozell and Jacobs, Inc., New York). June 1962. 65p.

A collection of fact sheets on U. S. nuclear power development projects is presented. All U. S. nuclear power projects are included. Data were checked with the organizations involved. Projects are classified by reactor types, using the coolant as the difference indicator. The U. S. approach to nuclear power development, electric company participation in nuclear power development, development by non-investor-owned utilities, and classification of power reactors are discussed. An index by companies is included. (M.C.G.)

**32582** (ORNL-TM-391) THE FUTURE ROLE OF BREEDER REACTORS IN THE NUCLEAR POWER INDUSTRY. T. W. Kerlin (Oak Ridge National Lab., Tenn.). Sept. 5, 1962. Contract W-7405-eng-26. 26p.

This study was made to estimate the latest prudent date for developing an economic breeder reactor system in the United States. The necessary criterion was that the expected United States nuclear power demand be satisfied for as long as possible with estimated low-cost (<$10/lb) uranium reserves. The total fuel required includes four factors: fuel to inventory the converters before the advent of breeders, fuel to replace burned fuel in the converters before the advent of breeders, fuel to inventory the breeders after they appear, fuel to replace burned fuel in the converters which still exist after the advent of breeders. The nuclear power growth rate was taken from recent studies by Harms and by Lane. Based on these studies, the most plausible conditions give 1981 and 1987 as the necessary transition date from a converter system to a breeder system for Harms' and Lane's projections, respectively. (auth)

**32583** (AEC-tr-5361) SINGLE-PASS STEAM SUPERHEATING EXPERIMENTAL INSTALLATION OF THE FIRST ATOMIC POWER PLANT REACTOR. V. V. Dolgov, V. Ya. Kozlov, L. A. Kochetov, O. A. Sudnitsyn, V. V. Sergeyev, and G. N. Ushakov. Translated from p.27-40 of "Proceedings of the Symposium on Power Reactor Experiments, held in Vienna, October 23-27, 1961. Vol. II." (A publication of the International Atomic Energy Agency, Vienna, 1962). (STI/PUB/51(Vol.II)(p.27-40)). 20p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 16, as abstract no. 11269.

**32584** WHEN WILL NUCLEAR PROPULSION ENTER THE MERCHANT MARINE? Y. Brunee and J. Finn. ACEC rev., No. 4, 12-31(1961). (In French)

In an evaluation of the time it will take for nuclear propulsion to become economically competitive, the quantitative importance of the factors conditioning the economy of nuclear chips is first determined. An attempt was then made to predict marine reactor development as a function of technological progress. The evaluation was made using a tanker of 64,000 dwt, traveling 15,000 miles at a speed of 18 knots. The PWR was the power source. For the ship study it was shown that the use of nuclear propulsion increases the cargo space by 9.25%. It was shown that the date of actual competition from nuclear ships is a function of two independent variables – the annual increase of the price of conventional fuel and the length of the route traveled. (J.S.R.)

**32585** TECHNICAL AND ECONOMIC DEVELOPMENT OF NUCLEAR POWER STATIONS. F. Louis. Bull. soc. roy. belge electriciens, No. 2, 11p. (Apr.-June 1961). (In French)

An economic comparison is established between electrical energy of classical thermal origin and that of nuclear origin. The cost evolution of these two energy sources is compared, and the principal reactor engineering developments that have contributed to significant cost reductions are reviewed. (J.S.R.)

**32586** STUDY OF THE DYNAMIC BEHAVIOR OF A PRESSURIZED WATER REACTOR AS A RESULT OF RAPID VARIATION OF THE LOAD. G. Cesare Bertolucci (FIAT S.p.A., Sezione Energia Nucleare, Turin). Rend. AEI (Venezia), 3p. (Sept.-Oct. 1959). (In Italian)

The behavior of a PWR as a result of rapid variation of

the turbine load is examined. It is shown how such variations are easily and promptly followed in nuclear reactors with short transient periods. (tr-auth)

**32587** CONVENTIONAL FIRED SUPERHEATER FOR SATURATED VAPOR PRODUCED IN A NUCLEAR PLANT. C. E. Rossi. Rend. AEI (Venezia), 6p. (Sept.-Oct. 1959). (In Italian)

After a description of some plants of the mixed type in which the saturated vapor produced by nuclear heat is superheated by conventional fuels, the cost of pressurized water reactor plant with and without a naphtha superheater is compared. On the basis of the comparison, technical and economic considerations are given from which possible advantages from the adoption of superheaters are deduced. (tr-auth)

**32588** THE 22nd PROJECT. L. Palacios and G. Velarde (Junta de Energia Nuclear, Madrid). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 15p. $0.50.

The DON reactor is to be a power prototype with a central loop for full-scale testing of fuel elements manufactured in Spain. It will be heavy-water-moderated and organic-cooled. Design data for both the reactor and the steam generator facility are given, and reactor core design is discussed. (A.G.W.)

**32589** THE DOUGLAS POINT NUCLEAR POWER STATION. J. S. Foster (Montreal Engineering Co. Ltd. and Atomic Energy of Canada Ltd., [Chalk River, Ont.]). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 29p. $0.50.

The Douglas Point station including the reactor (designated CANDU) is described. Special design principles to minimize loss of heavy water, radiation hazards control, the operating staff, cost of the plant, and the construction schedule are discussed. (A.G.W.)

**32590** PRELIMINARY DESIGN OF A NUCLEAR PROPULSION PLANT FOR A TURBO TANKER OF 70,000 TONS DISPLACEMENT WITH FULL LOAD. M. Chiappini, G. Previti, and A. Ridolfo. p.79-119 of "Atti del Congresso Scientifico, Sezione Nucleare, Indetto in Occasione della V Rassegna Internazionale Elettronica Nucleare—Giugno 1958." Rome, Palazzo dei Congressi—E.U.R., [1958]. (In Italian)

In the preliminary design of a nuclear propulsion plant for a turbo-tanker, the most characteristic problems are studied. The placement of the nuclear plant, the engineering of the nuclear and conventional plants, the instrumentation, and the risks are considered. (J.S.R.)

**32591** THE FUTURE AND POTENTIAL OF HEAVY WATER REACTORS. Preprint. [Ottawa], Canadian Nuclear Association, 1962. 15p. $0.50.

Aspects of heavy-water-moderated power reactors discussed by a six-member panel include the following: summary of reactor problems still needing study; methods of estimating nuclear power generating costs; comparison of reactor financing conditions in the United States and Canada; general direction of research and development program in the United States; feasibility of using enriched U in heavy-water reactors. (A.G.W.)

**32592** PROSPECTS FOR ELECTRONUCLEAR PRODUCTION IN ITALY. Sergio Pittori (Comitato Nazionale per l'Energia Nucleare, Italy). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 7p. $0.50.

Italy's energy needs and sources of supply are summarized. It is concluded that, because a large proportion of traditional sources of energy must be imported, development of a nuclear power program in Italy is very important. Nuclear power plants under construction and research projects both in progress and planned are described briefly. (A.G.W.)

**32593** THERMAL AND HYDRAULIC PERFORMANCE OF BOILING WATER REACTORS. S. Levy (General Electric Co., San Jose, Calif.). Preprint Paper No. 89. New York, Engineers Joint Council, 1962. 26p.

Both results of previous developmental work and specific problems requiring further investigation are summarized for the following major thermal and hydraulic areas: critical heat flux, steam voids, hydraulic oscillations, and two-phase pressure drop. Thermal and hydraulic operating experience at the Dresden plant is reviewed briefly. (A.G.W.)

**32594** THERMAL DESIGN ASPECTS OF GAS-COOLED REACTORS. Robert Katz and Marius Troost (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Preprint Paper No. 91. New York, Engineers Joint Council, 1962. 30p.

The thermal design of two gas-cooled reactors, the High Temperature Gas-Cooled Reactor (HTGR) and the Experimental Beryllium Oxide Reactor (EBOR) is discussed. The thermal design aspects of these two systems are different and each system is treated individually. The basic temperature criteria of each system are identified, and the influence of heat transfer coefficients, hot-spots, and transient analysis on the temperature criteria is indicated. (auth)

**32595** ASTM STANDARDS AND RECOMMENDED PRACTICES FOR METALLIC COMPONENTS OF WATER-COOLED NUCLEAR POWER REACTORS. M. A. Cordovi (The International Nickel Co., Inc., New York) and C. R. Johnson. Preprint Paper No. 96. New York, Engineers Joint Council, 1962. 14p.

Activities of ASTM in standardization of reactor materials are discussed. Tables of materials specifications and inspection methods are given. (A.G.W.)

**32596** RELIABILITY REQUIREMENTS FOR NUCLEAR POWER STATIONS. George C. Laurence (Atomic Energy Control Board, Ottawa). Preprint Paper No. 97. New York, Engineers Joint Council, 1962. 13p.

Reactor safety devices and rules are reviewed. Emphasis is placed on the Canadian practice of keeping protective instruments in operation and maintaining a degree of reactor shutdown capacity and alarm capability during periods of reactor shutdown and maintenance. Protective devices and containment provisions for large nuclear power stations should be designed to be effective for 99 to 99.9% of the combined operating, shutdown, and maintenance time. Duplication of devices assists in achieving this goal. (A.G.W.)

**32597** NUCLEAR REACTOR FOR GENERATION OF POWER AND FOR IRRADIATION OF A LIQUID ORGANIC MATERIAL. (to Esso Research and Engineering Co.). French Patent 1,207,919. Feb. 19, 1960.

A reactor consisting of a reaction chamber, conduit means for a fluid coolant for the reaction chamber, thermal insulation arranged about the reaction chamber, and a chamber for radio-conversion reaction of liquid organic material disposed about and surrounding the thermal insulation is described. The spacial relation of the chamber containing the liquid organic material to the reaction chamber is such that the liquid organic material absorbs gamma rays and fast neutrons, at least 1% and usually 4% of the total nuclear energy released, and supplies at least 25% of

the moderation necessary to sustain the nuclear reaction. The amount and arrangement of the thermal insulation are dependent on the difference between the temperatures desired in the coolant and the liquid organic material being processed. This temperature difference is at least ±30°C. (NPO)

**32598** IMPROVEMENTS RELATING TO INSTALLATIONS, ESPECIALLY TO NUCLEAR POWER PLANTS IN WHICH A FORCED CIRCULATION OF A RADIOACTIVE LIQUID IS TO BE ESTABLISHED. (to Commissariat à l'Énergie Atomique). French Patent 1,238,900. Sept. 11, 1960.

In order to get minimum dimensions for the space occupied by the means effectuating the forced circulation of a radioactive liquid, e.g., the coolant of a reactor, a centrifugal pump is provided with a preferably forged exit header having the shape of a torus and leading the fluid in a centripetal direction towards the pump exit situated in the axis of the pump system. Suitably the pump is used for liquid sodium and is situated on the bottom of a cylindrical container with vertical axis partially filled with the liquid sodium. Above the container a biological shield is provided on which the pump motor is placed, the driving axle being placed in the container axis. The liquid sodium enters the pump from above and leaves it at the bottom via the forged header. (NPO)

**32599** IMPROVEMENTS RELATING TO NUCLEAR POWER PLANTS. (to État Francais). French Patent 1,253,859. Jan. 9, 1961.

For heat transfer in a pressurized water reactor, the piping for the coolant generally is of large cross sections to limit pressure drop. The piping requires bulky shielding and presents problems which are difficult to solve. In order to prevent this, the entrance and exit ducts of each coolant circuit are concentrically disposed, only their exterior being pressure resistant, while the inner one is completely flexible or rigid in combination with a bellow or other means absorbing the differences in expansion. The two ducts penetrate into a distributor chamber divided into two portions by a wall, these portions communicating with the pumping and heat exchange means. Preferably the distributor chamber is mounted at the top of a cylindrical heat exchanger casing. The inner duct, led through the center of the heat exchanger, communicates by its lower extremity with the lower header of the heat exchanger, while its upper header is formed by the lower of the portions of the distributor chamber. (NPO)

**32600** NUCLEAR STEAM-POWER PLANT WITH HETEROGENEOUS NUCLEAR REACTOR. (to Gebrüder Sulzer, Aktiengesellschaft). Swiss Patent 347,384. Aug. 15, 1960.

A nuclear steam-power plant with heterogeneous reactor in which heat is separately abstracted from the moderator for cooling of the latter and for subsequent use is characterized by the fact that the moderator is transmitted to the steam cycle, and that at least two heat exchangers are provided, separated by at least one extraction (bleeding) steam pre-heater, and series-mounted with the feed-liquid preheaters of the steam cycle. (OTS)

**32601** NUCLEAR STEAM-POWER PLANT WITH HETEROGENEOUS NUCLEAR REACTOR. (to Gebrüder Sulzer, Aktiengesellschaft). Swiss Patent 347,385. Aug. 15, 1960.

A nuclear steam power plant with heterogeneous nuclear reactor, in which heat is separately abstracted from the moderator for cooling of the latter, and for subsequent use, is characterized by the fact that the moderator heat is transmitted to the steam cycle, and that at least one heat exchanger is provided for the heating of the additional feed water required for making up the losses in the working liquid during the steam-generating cycle. (OTS)

## Research Reactors

**32602** (ANL-6587) PHYSICS ANALYSIS OF THE JUGGERNAUT REACTOR. D. P. Moon (Argonne National Lab., Ill.). July 1962. Contract W-31-109-eng-38. 47p.

The JUGGERNAUT is an intermediate-power research reactor designed and constructed as a supporting facility for chemistry and physics research. The design of this reactor is similar to that of the ARGONAUT, and those methods of evaluating the nuclear characteristics of the ARGONAUT which gave good agreement with experimental data were considered applicable to the analysis of the JUGGERNAUT. The analyses for both the JUGGERNAUT and the ARGONAUT were based on a modified two-group theory. The criticality calculations were carried out with the IBM-704 and the two-dimensional PDQ code. Reactivity effects were calculated by hand by means of perturbation techniques, with the real and adjoint fluxes obtained from PDQ calculations. (J.R.D.)

**32603** (ANL-6595) A SUBCRITICAL PLUTONIUM-FUELED FAST REACTOR CORE (ZPR-III ASSEMBLY 37). P. I. Amundson, R. Jiacoletti, J. K. Long, and R. L. McVean (Argonne National Lab., Idaho Falls, Idaho). July 1962. Contract W-31-109-eng-38. 25p.

A subcritical fast reactor, fueled with Pu, is described. Calculations and experimental measurements of neutron flux and gamma dose rates near the bare core face are reported, as well as the core temperature increase caused by Pu alpha and gamma heating. (auth)

**32604** (EIR-27) BULK SHIELDING STUDIES AT THE REACTOR SAPHIR. J. M. Pictet and A. Etemad (Switzerland. Eidgenössisches Institut für Reaktorforschung, Würenlingen). July 1962. 53p.

Experiments concerning bulk shielding, especially neutron and gamma radiation attenuation by water, concrete, baryte concrete, and iron are described. The shielding facility which was installed at the SAPHIR reactor is described along with methods used for measuring neutron fluxes and gamma dose rates. Discussions on computation and interpretation of results are included. (J.R.D.)

**32605** (NP-12045) FINAL SAFEGUARDS REPORT TO THE U. S. ATOMIC ENERGY COMMISSION FOR THE CORNELL UNIVERSITY ZERO POWER REACTOR. Selwyn S. Berg (Cornell Univ., Ithaca, N. Y. Nuclear Reactor Lab.). May 1962. 247p. (CURL-4)

The Zero Power Reactor facility is an experimental system for exponential and miniature lattice studies in conjunction with the TRIGA, MK II Reactor and critical experiments. The reactor has light water moderated cores with high density, low enrichment Al clad $UO_2$ fuel. The maximum credible accident for this core was predicted on an assumed run-away caused by a ramp of 0.05% $\sigma$ k/k sec. It is shown that such an accident can be contained in the Zero Power Reactor cell. A description of the building, reactors, and administration is included to show that the facility and its management are safe for operation. (J.R.D.)

**32606** (NP-12048) HAZARDS SUMMARY FOR THE L-77 LABORATORY REACTOR FOR THE UNIVERSITY OF NEVADA, RENO. (Nevada. Univ., Reno). Sept. 14, 1962. 83p.

A hazards summary report for the planned installation and operation of an L-77 Laboratory Reactor of the University of Nevada is presented. Site data, including information on the geography, geology, seismology, climatology, and hydrology of the area in which the reactor will be installed are included. The reactor site and administration of the reactor facility are described along with the reactor, its uses, and its performance characteristics. Analyses of the nuclear, radiation, and operational hazards are also included. (auth)

**32607** (R61DSD13) A SUMMARY OF PULSED REACTOR DESIGNS AND FACILITIES. A. L. Kaplan (General Electric Co. Electronics Div., Syracuse, N. Y.). July 10, 1961. 154p.

A description of the pulsed reactor designs and facilities currently in the operating or design stages is presented. Among the pulsed reactors described are the KEWB, TRIGA, GODIVA I, GODIVA II, KUKLA, Sandia Pulsed Reactor, and the ORNL SUPERGODIVA. The development and operation history, physical characteristics, nuclear characteristics, details of the pulsing operation, instrumentation safety in operation, and possibilities for improvements of the reactor are all described in detail. In addition, a description of the experimental and irradiation facilities available at each reactor site is included. A summary of the important nuclear characteristics of each pulsed reactor that allows easy comparison of these characteristics for all the reactors is also included. (auth)

**32608** (SGAE-62/1B) VERLAUF DES THERMISCHEN SPEKTRUMS DES ASTRA-REAKTORS. (Course of the Thermal Spectrum of the ASTRA-Reactor). F. Woloch (Österreichische Studiengesellschaft für Atomenergie G.m.b.H., Vienna). Mar. 1962. 13p.

The pattern of the thermal spectrum of the ASTRA reactor was measured in the energy interval from 0.0336 to 0.1563 ev. The effective neutron temperature is under 0.0336 ev. (tr-auth)

**32609** RESEARCH USING A SWIMMING POOL REACTOR. Martin Johns (McMaster Univ., Hamilton, Ont.). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 16p. $0.50.

The traditional roles of teaching and research in universities, the history of nuclear research in Canadian universities, and the goals of nuclear research are discussed. Research projects being carried out at McMaster in connection with the swimming pool reactor are reviewed. Thermal neutron fission of $U^{235}$ is discussed with emphasis on the relative numbers of prompt and delayed neutrons emitted. (A.G.W.)

**32610** OPERATION OF McMASTER RESEARCH REACTOR. W. H. Fleming (McMaster Univ., Hamilton, Ont.). Preprint. [Ottawa], Canadian Nuclear Association, 1962. 8p. $0.50.

The McMaster Research Reactor is described briefly. Its operating history, costs, and problems and its current and future experimental programs are reviewed. (A.G.W.)

# SPACE APPLICATIONS AND TECHNOLOGY

*Refer also to abstracts 31743, 31782, and 31783.*

**32611** (JPL-TR-32-281) NUCLEAR ELECTRIC SPACECRAFT FOR UNMANNED PLANETARY AND INTERPLANETARY MISSIONS. Dwain F. Spencer, Leonard D. Jaffe, John W. Lucas, Owen S. Merrill, and John I. Shafer (California Inst. of Tech., Pasadena. Jet Propulsion Lab.). Apr. 25, 1962. Contract NAS-7-100. 11p.

Advanced electric propulsion spacecraft are shown to exhibit a unique capability in performing planetary and interplanetary missions. In particular, performance analyses indicate that an electric propulsion spacecraft of 45,000 lb initial weight can perform all fifteen high-energy missions which are of interest to space scientists. Comparable chemical and nuclear heat exchanger spacecraft can perform only seven and nine of these missions, respectively. Based on what are believed to be realistic estimates of system weight, the two powerplant types considered, thermionic and turbogenerator, appear to have comparable specific weights (12 to 14 lb/kwe) at the 0.3 to 1.5 Mwe power level. This provides a strong incentive to adequately support both concepts, at least in the early phases of research and development. System considerations regarding the utilization of these powerplants indicate a preference for the static (thermionic) type. For example, attitude control requirements of the spacecraft are minimized with the thermionic system by eliminating rotating mechanical devices and by providing a smaller radiator area, thus a less severe dynamic stability problem at the same power level. Probably the most important factor is the inherent reliability associated with a static system. In addition, demonstration of this reliability is feasible in ground testing. Because low-thrust propulsion units must operate for unusually long times, this factor will be extremely important. It is recognized that many problems exist in developing a flyable thermionic or turbogenerator powerplant; however, based on the preceding arguments, a highly accelerated research and development program for both systems is deemed warranted. (auth)

**32612** (NP-12046) FEASIBILITY STUDY TOWARD DEVELOPMENT OF RADIATION RESISTANT SOLAR CELL. Monthly Report, August 1—August 31, 1962. S. Kaye (Electro-Optical Systems, Inc., Pasadena, Calif.). Sept. 15, 1962. Contract NAS7-92. 11p. (EOS-2080-ML-10)

Three graded base p-on-n cells were subjected to irradiation testing. The results indicated a greater resistance to irradiation than is found in normal p-on-n cells. An investigation of the method of measurement of the initial efficiency of cells in sunlight indicated that there were some errors occurring and that it will therefore be necessary to re-evaluate the initial efficiencies of all cells. (auth)

**32613** (NP-12074) THE POTENTIAL OF NUCLEAR SPACE TRANSPORT SYSTEMS. (Douglas Aircraft Co., Inc., Santa Monica, Calif.). Mar. 1960. 24p. (SM-37427)

The viewpoint of the Douglas Aircraft Company as of Jan. 1960, on the application of nuclear rockets to space flight is presented. The basic capabilities and operating characteristics of nuclear rocket propulsion systems are first reviewed. Vehicle size and performance characteristics are discussed for lunar and interplanetary missions. Operating cost estimates are presented for lunar and Martian missions for both cargo and personnel transport. Various problems relating to the utilization of a nuclear energy source in a space vehicle, including that of shield requirements for manned systems, are discussed. It is indicated that nuclear space vehicles will provide personnel and cargo transport capabilities to the moon and nearer planets at costs of the same order as intercontinental air transport rates. Some applications of nuclear vehicles to peaceful and military space missions are discussed. (auth)

**32614** (TID-11429) MATERIALS PROBLEMS IN THE ROVER PROGRAM. Donald P. MacMillan (Los Alamos Scientific Lab., N. Mex.). [1959]. Contract [W-7405-eng-36]. 27p. (LADC-4210)

Problems in fuel element development for the Rover program are discussed. Properties of refractory materials which remain solid above 2500°C are described. Tensile and compressive creep properties of graphite were determined. The compatibility of fuel element materials with the hydrogenous working fluid was also considered. The effect of composition on the properties of graphite is discussed. (M.C.G.)

**32615** WANTED: RADIATION-RESISTANT SOLAR CELLS. Michael F. Wolff. Electronics, 35: No. 38, 28-9 (Sept. 21, 1962).

The possible effects of the July 9 nuclear test and other tests on the use of solar cells in future satellites are discussed briefly. Several possible ways of increasing the radiation resistance of solar cells are described. Telstar uses n-on-p rather than p-on-p cells and is performing satisfactorily. Other ways are increasing the base resistivity, using graded-base cells, and using gallium arsenide instead of silicon. (D.L.C.)

**32616** PLASMA JET PROPAGATION IN INUNDATED SPACE. Hsien Hsiang Ch'un. Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk, Mekham. i Mashinostr., No. 3, 38-45 (May-June 1962). (In Russian)

Plasma jet flow in space was analyzed and formulas were derived for infinite axis velocity and enthalpy in the main plasma jet region. Experimental data are compared with theoretical regularities in a water-stabilized plasma jet. An attempt was made to analyze turbulent gas jets (without considering dissociation and ionization) and to determine the regularities in plasma jet flow by resolving the motion and enthalpy equations and by applying generalized mass velocity. Calculations postulate that the plasma jet is mixed with an identical medium, for instance air plasma with air. (R.V.J.)

# WASTE DISPOSAL AND PROCESSING

**32617** (HW-SA-2515) THE HANFORD PROGRAM FOR MANAGEMENT OF HIGH-LEVEL WASTE. R. E. Tomlinson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [July 30, 1962]. Contract AT(45-1)-1350. 40p.

A description of a proposed Hanford waste management program is presented. Consideration is given to the magnitude and characteristics of these wastes, the geology and climate of the area, the potential usefulness of selected fission products, and the relative costs of the various alternatives available. A combination of waste fractionization and in-tank solidification is recommended as the best approach to high-level waste management. It is noted that conclusions concerning Hanford waste management may not apply elsewhere. (J.R.D.)

**32618** (HW-SA-2592) POT CALCINATION OF SIMULATED HIGH-LEVEL RADIOACTIVE WASTES— MELT FORMATION. J. J. Shefcik (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 15, 1962. Contract AT(45-1)-1350. 18p.

Currently nuclear fuels are being processed on a large scale for recovery of valuable fission products and these recovery operations result in over fifty million gallons of radioactive wastes. Problems of safe and economical containment of this waste are briefly reviewed, and several alternate schemes for storage are outlined. The immobilization of the wastes by conversion to a solid and storage in high-integrity containers is discussed. Various methods for conversion of the wastes to solids include drying-denitration processes of fluid bed reactions, radiant spray calcination, rotary kiln calcination, submerged combustion, and pot calcination. Problems associated with the reactor-container employed in the pot calcination process are discussed in detail. Emphasis is placed on chemical-physical methods of attacking and minimizing the problems associated with self-heating of the wastes in this container. (C.H.)

**32619** (HW-SA-2707) APPRAISING HANFORD WASTE DISPOSAL BY INTEGRATION OF FIELD TECHNIQUES. D. J. Brown, R. E. Brown, and W. A. Haney (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Aug. 21, 1962. Contract AT(45-1)-1350. 17p.

Low- and intermediate-level liquid radioactive wastes have been discharged to the ground at Hanford for the past 16 yr. Field methods and techniques developed to help trace and define the movement of waste liquids through the soil are reviewed. The value is stressed of integrating data from several sources in evaluating ground water contamination patterns and movement. Data on vertical flow in wells, concentrations of specific $\beta$-$\gamma$ emitters in the ground water, temperature gradients, and data on the hydrology and geology of the region all provide valuable data applicable in predicting the movement of radioactive wastes. (C.H.)

**32620** (ORNL-3356) EVALUATION OF ULTIMATE DISPOSAL METHODS FOR LIQUID AND SOLID RADIOACTIVE WASTES. IV. SHIPMENT OF CALCINED SOLIDS. J. J. Perona, R. L. Bradshaw, J. O. Blomeke, and J. T. Roberts (Oak Ridge National Lab., Tenn.). Oct. 18, 1962. Contract W-7405-eng-26. 26p.

The costs of shipping calcined Purex and Thorex wastes were calculated assuming the wastes were produced by a plant processing 1500 metric tons/year of U converter fuel at a burnup of 10,000 Mwd ton, 270 metric tons/year of Th converter fuel at 20,000 Mwd/ton. Calculations were made for Purex waste calcined in acidic and reacidified (after alkaline storage) forms and for Thorex waste calcined in acidic and reacidified forms and with constituents added for producing an acidic Thorex glass. Shipping casks of Fe, Pb, and U were considered at $0.25, 0.75, and $5.00/lb. Casks were cylindrical in shape and up to 60 in. ID, which is large enough to contain four 24-in.-dia., nine 12-in.-dia., or thirty six 6-in.-dia. cylinders of calcined waste. Cask weights ranged up to 100 tons. The cask design did not include liquid coolants or mechanical cooling equipment, and couriers were assumed not required. Minimum waste age prior to shipping because of temperature limitations ranged up to 11 years for acidic Purex with four 24-in.-dia. cylinders/cask. Rail freight rates of $24, $44, and $65/ton were assumed for distances of 500, 1000 and 1500 miles with rates 30% less for the return of the empty casks. Total costs were lowest in all cases for lead casks, and for 1000 mile round-trip shipments ranged from $5.5 \times 10^{-4}$ mill/kwh$_e$ for acidic Purex waste at 30 years of age in casks containing four 24-in.-dia. cylinders to $1.6 \times 10^{-2}$ mill/kwh$_e$ for acidic Thorex at 0.33 years in casks containing four 6-in.-dia. or one 12-in.-dia. cylinders. Costs for 3000 mile round-trip shipments were higher by factors of 2.0 to 2.4. (auth)

**32621** THE HANDLING OF WASTE IN THE REGION OF THE KARLSRUHE ATOMIC RESEARCH CENTER. Stefan Krawczynski. Gas- u.Wasserfach, 101: 1-9(Sept. 1960). (KFK-36) (In German)

In an earlier work (Gas- u. Wasserfach 100, 906(1959)) methods for the treatment of radioactive wastes were described. The present work shows the practical procedures using as an example the treatment of waste waters in the region of the Karlsruhe Atomic Research Center. (tr-auth)

**32622** THE USE OF CERAMIC SPONGES FOR HIGH LEVEL WASTE DISPOSAL. C. W. Christenson (Los Alamos Scientific Lab., N. Mex.), R. G. Thomas, W. H. Adams, E.B. Fowler, and G. D. Kelly. Preprint Paper No. 31. Oxford, Pergamon Press Ltd., 1962. 36p. $0.70.

Liquid radioactive wastes containing aluminum nitrate and nitric acid can be disposed of by soaking in ceramic sponges, evaporating the liquid, and repeating the cycle. The sponges are then fired to about 1300°C at which temperature the radioactivity is fixed in the ceramic body. Cost of this treatment of high-level wastes is estimated to be of the order of $0.60/gal. A method of determining heat generation on storage is presented. (A.G.W.)

**32623** CONSIDERATIONS ON THE SITING OF OUTFALLS FOR THE SEA DISPOSAL OF RADIOACTIVE EFFLUENT IN TIDAL WATERS. R. T. P. Whipple (United Kingdom Atomic Energy Authority, Harwell, Berks, Eng.). Preprint Paper No. 46. Oxford, Pergamon Press Ltd., 1962. 24p. $0.70.

In siting outfalls for sea disposal of radioactive waste factors which must be considered include local tidal currents, sea currents, eddy diffusion, and the mechanism of dispersion at the end of the pipeline. Methods of determining the influence of each of these factors are discussed. Experiments performed in the summer and autumn of 1956 (known as Exercise Mermaid) in the English Channel off the Dorset coast are described. These experiments attempted to provide data on the tidal eddy in East Bay and to measure eddy diffusion. (A.G.W.)

# CORPORATE AUTHOR INDEX

**This index contains entries for all report literature and, in addition, for certain published literature items for which it is felt that a corporate approach is especially desirable, e.g., symposia, conference proceedings, and meetings.**

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**Because of problems involving the mechanical preparation of this index, all accent marks are omitted. The following changes in spelling have been introduced to reduce some of the confusion which might result from omitting the accents:**

| | | |
|---|---|---|
| æ | becomes | ae |
| ö | | oe |
| ø | | oe |
| ü | | ue (except in transliterated Chinese names) |

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**As an aid to the users of this index, references to report numbers, where appropriate, are included after the abstract number of the citation.**

**The number preceding the colon is the *NSA* volume number, and the number following is the abstract number in that volume. The designation (R) following the abstract number indicates that the abstract is of a progress report; (P) indicates a patent; and (T) indicates a translation. Abstracts for reports other than progress reports carry no letter designation. Published literature (journal article or book) is identifiable by the absence of a report number.**

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| 5069 | 16-31902 | p.117-20 of "Proceedings of an International Conference on Instrumentation for High-Energy Physics." New York Interscience Publishers, 1961 |
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| 753 | 16-32033 | Dep.; $0.50(OTS) |
| 754 | 16-31541 | Dep.; $0.50(OTS) |
| 761 | 16-31817 | Dep.; $0.50(OTS) |
| **EIR-** | **(Swiss)** | |
| 25 | 16-31818 | Dep.(mc) |
| 27 | 16-32604 | Dep.(mc) |
| **EOS-** | **(Non-AEC)** | |
| 1470-Final | 16-32471 | See AD-271711 |
| 2080-ML-10 | 16-32612 | See NP-12046 |
| **ER-** | **(Misc.)** | |
| 4461 | 16-32079 | See NAA-SR-6306 |
| **EURAEC-** | | |
| 179 | 16-32103 | Dep.(mc); $2.60(fs), $0.89(mf) OTS |
| 227 | 16-32084 | Dep.(mc); $5.60(fs), $2.00(mf) OTS |
| 237 | 16-32158 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 250 | 16-32124 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 259 | 16-32032 | See CEND-152 |
| 277 | 16-32112 | See GEAP-3771-3 |
| 289 | 16-31791 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 296 | 16-32125 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 310 | 16-32094 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 311 | 16-32535 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 328 | 16-32126 | Dep.(mc); $4.60(fs), $1.49(mf) OTS |
| 333 | 16-32536 | Dep.(mc); $3.60(fs), $1.19(mf) OTS |
| 339 | 16-31551 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 370 | 16-32144 | Dep.(mc); $4.60(fs), $1.43(mf) OTS |
| 405 | 16-32111 | Dep.(mc); $2.60(fs), $1.07(mf) OTS |
| 418 | 16-31799 | See UNC-5025 |
| **EXP-NRX-** | **(Canadian)** | |
| 5603 | 16-32141 | See CRFD-1092 |
| **FN-E-** | **(Italian)** | |
| 20 | 16-32536 | See EURAEC-333 |
| 21 | 16-32094 | See EURAEC-310 |
| 22 | 16-32535 | See EURAEC-311 |
| 26 | 16-32111 | See EURAEC-405 |
| **FTD-TT-** | **(Non-AEC)** | |
| 62-678 | 16-31989 | OTS |
| 62-817 | 16-31643 | OTS |
| **FZM-** | **(Non-AEC)** | |
| 1943 | 16-32145 | $1.75(OTS) |
| **GA-** | **(Misc.)** | |
| 2925 | 16-32502 | J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research 4: |

| Report No. | Abstract No. | Availability |
|---|---|---|
| | | 253-62(1962) |
| 3083* | 16-32391 | |
| 3122 | 16-32357 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **GAMD–** | **(Misc.)** | |
| 3032 | 16-32572 | Dep.(mc); $5.60(fs), $1.79(mf) OTS |
| **GEAP–** | **(Misc.)** | |
| 3644 | 16-32358 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 3743(Pt.III) | 16-32146 | Dep.(mc); $4.60(fs), $1.61(mf) OTS |
| 3771-3 | 16-32112 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 3877 | 16-32573 | Dep.; $3.00(OTS) |
| 3944 | 16-32359 | Dep.(mc); $11.50(fs), $4.73(mf) OTS |
| 3956 | 16-32537 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 4008 | 16-32392 | Dep.(mc); $4.60(fs), $1.58(mf) OTS |
| 4053-1 | 16-32538 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **GEMP–** | | |
| 15A | 16-32034 | Dep.; $1.75(OTS) |
| **GP–** | **(Non-AEC)** | |
| 96 | 16-32481 | See NP-12054 |
| **HW–** | | |
| 34368 | 16-32095 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 56489 | 16-32113 | $1.60(fs), $0.80(mf) OTS |
| 65739 | 16-31792 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 68954(Rev.2) | 16-31639 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 71054 | 16-31673 | Dep.(mc); $3.60(fs), $1.40(mf) OTS |
| 72086 | 16-32096 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 72802 | 16-31955 | Dep.; $2.00(OTS) |
| 73902 | 16-31793 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 73915 | 16-32539 | Dep.; $3.50(OTS) |
| 74333 | 16-31819 | Dep.; $1.00(OTS) |
| 74622 | 16-32147 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **HW-SA–** | | |
| 2119 | 16-32540 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2394 | 16-32148 | Dep.(mc); $4.60(fs), $1.52(mf) OTS |
| 2413 | 16-31820 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2425 | 16-32149 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2428 | 16-32097 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2514 | 16-31984 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2515 | 16-32617 | Dep.(mc); $3.60(fs), $1.40(mf) OTS |
| 2592 | 16-32618 | $1.60(fs), $0.80(mf) OTS |
| 2612 | 16-31542 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 2646 | 16-31524 | Nature 195: 1217-18(1962) |
| 2655 | 16-31985 | Dep.(mc); $3.60(fs), $1.13(mf) OTS |
| 2707 | 16-32619 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2718 | 16-31986 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 2728 | 16-31956 | Dep.(mc); $3.60(fs), $1.28(mf) OTS |
| 2749 | 16-32574 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **IA–** | **(Non-AEC)** | |
| 712 | 16-31543 | Dep.(mc) |
| 730 | 16-32001 | Dep.(mc) |
| 739 | 16-31544 | Dep.(mc) |
| 753 | 16-31471 | Dep.(mc) |
| 757 | 16-32360 | Dep.(mc) |
| 759 | 16-32015 | Dep.(mc) |
| 761 | 16-32361 | Dep.(mc) |
| **IDO–** | | |
| 14304 | 16-31674 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 19021(Vols.I&II) | 16-32575 | Dep.; $7.00(OTS) |
| 28590 | 16-32576 | Dep.; $3.00(OTS) |
| 28591 | 16-32114 | Dep.; $1.00(OTS) |
| **IS–** | | |
| 304 | 16-32054 | p.47-58 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962 |
| 325 | 16-32063 | p.175-84 of "Rare Earth Research." New York, Gordon and Breach Science Publishers, 1962 |
| 363 | 16-31678 | Ind. Eng. Chem., Process Design Develop. 1: 305-9(1962) |
| 417 | 16-31584 | Dep.; $2.50(OTS) |
| 435 | 16-31555 | Anal. Chem. 34: 1387-9(1962) |
| **JEN–** | **(Spanish)** | |
| 102-DNe/I-9 | 16-32035 | Dep.(mc) |
| **JPL-TR–** | **(Non-AEC)** | |
| 32-281 | 16-32611 | |
| **JPRS–** | **(Non-AEC)** | |
| 14484 | 16-32127 | OTS |
| **K–** | | |
| 1548 | 16-31530 | Dep.; $1.00(OTS) |
| 1550 | 16-31987 | Dep.; $0.50(OTS) |
| **KFK–** | **(German)** | |
| 36 | 16-32621 | Gas- u. Wasserfach 101: 1-9(1960) |
| 78 | 16-32022 | Z. Naturforsch., 16a: 955-60(1961) |
| 90 | 16-32016 | Chem.-Ing.-Tech.: 34: 7-10(1962) |
| 92 | 16-32017 | Chem.-Ing.-Tech. 34: 105-8(1962) |
| 105 | 16-32115 | Dep.(mc) |
| **KR–** | **(Norwegian)** | |
| 22 | 16-31350 | Dep.(mc) |
| **LA–** | | |
| 2723 | 16-31821 | Dep.; $0.50(OTS) |
| 2737 | 16-32098 | Dep.; $1.00(OTS) |
| 2746 | 16-32577 | Dep.; $1.25(OTS) |
| **LADC–** | | |
| 4210 | 16-32614 | See TID-11429 |
| 5173 | 16-32023 | Dep.(mc); $6.60(fs), $2.30(mf) OTS |
| 5198 | 16-31545 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 5267 | 16-32393 | Dep.(mc); $3.60(fs), $1.28(mf) OTS |
| 5323 | 16-31472 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 5367 | 16-32394 | Dep.(mc); $10.50(fs), $4.28(mf) OTS |
| 5378 | 16-31351 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 5388 | 16-32395 | Dep.(mc); $4.60(fs), $1.61(mf) OTS |
| **LAL–** | **(French)** | |
| 1035 | 16-32458 | Dep.(mc) |
| **LAMS–** | | |
| 2546(Suppl.) | 16-32478 | Dep.; $0.50(OTS) |
| 2744 | 16-32261 | Dep.; $0.75(OTS) |
| **MATT–** | | |
| 80 | 16-31749 | p.476-82 of "1961 Transactions of the Eight National Vacuum Symposium Combined with the 2nd International Congress on Vacuum Science and Technology. Vol. 1." Oxford, Pergamon Press, 1963 |
| 86 | 16-32204 | J. Math. Phys. 3: 806-28(1962) |
| 108 | 16-32203 | J. Math. Phys. 3: 778-92(1962) |
| 127 | 16-32479 | Dep.(mc); $5.60(fs), $1.73(mf) OTS |
| **MF–** | **(Misc.)** | |
| 31 | 16-32484 | See NYO-9193 |
| **MITNE–** | | |
| 17 | 16-32362 | Dep.(mc); $15.00(fs), $6.92(mf) OTS |
| 24 | 16-32578 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **ML–** | **(Misc.)** | |
| 917* | 16-32480 | $3.60(fs) OTS |
| **MND-MD–** | | |
| 2560-5 | 16-32579 | Dep.(mc); $12.50(fs), $5.48(mf) OTS |
| **MR-N–** | **(Non-AEC)** | |
| 289 | 16-32117 | See NARF-62-12T |
| 294 | 16-32150 | See NARF-62-8T |
| 295 | 16-32151 | See NARF-62-9T |
| **NAA-SR–** | | |
| 6306 | 16-32079 | Dep.(mc); $4.60(fs), $1.70(mf) OTS |
| 6542 | 16-31822 | Dep.; $0.75(OTS) |
| 7432 | 16-32519 | Dep.; $0.75(OTS) |
| **NAA-SR-Memo–** | | |
| 4965 | 16-31794 | Dep.(mc); $7.60(fs), $2.57(mf) OTS |
| 6921 | 16-32116 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 7419 | 16-32024 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 7538 | 16-32036 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 7570 | 16-32541 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| **NARF–** | **(Non-AEC)** | |
| 62-8T | 16-32150 | $4.60(fs) OTS |
| 62-9T | 16-32151 | |
| 62-12T | 16-32117 | $3.60(fs) OTS |

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| **NASA-TN–** | **(Misc.)** | |
| D-998* | 16-32118 | $1.00(OTS) |
| D-1214* | 16-31795 | $1.25(OTS) |
| D-1360* | 16-32252 | |
| D-1361* | 16-32253 | |
| D-1407* | 16-32580 | |
| **NAVWEPS–** | **(Non-AEC)** | |
| 7738 | 16-32100 | Included in NOTS-TP-2698 |
| **NBS-MON–** | **(Misc.)** | |
| 50* | 16-32172 | $0.35(GPO) |
| **NMI–** | **(Misc.)** | |
| 7214 | 16-32099 | Dep.(mc); $2.60(fs), $1.07(mf) OTS |
| **NOTS-TP–** | **(Non-AEC)** | |
| 2698 | 16-32100 | $1.60(OTS) |
| **NP–** | **(AEC File No. for Non-AEC Reports)** | |
| 11745 | 16-32396 | Dep.(mc) |
| 12012 | 16-32397 | |
| 12020 | 16-31692 | $8.10(fs) OTS |
| 12032 | 16-32274 | Dep.(mc) |
| 12034 | 16-32275 | Dep.(mc) |
| 12035 | 16-32276 | Dep.(mc) |
| 12036 | 16-31796 | |
| 12038 | 16-32581 | |
| 12045 | 16-32605 | $16.00(fs), $7.61(mf) OTS |
| 12046 | 16-32612 | |
| 12048 | 16-32606 | Dep.(mc); $8.10(fs), $2.69(mf) OTS |
| 12052 | 16-32173 | |
| 12053 | 16-31958 | |
| 12054 | 16-32481 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 12058 | 16-32482 | $3.60(fs) OTS |
| 12062 | 16-32002 | |
| 12063 | 16-32003 | |
| 12064 | 16-32004 | |
| 12065 | 16-32005 | |
| 12066 | 16-32006 | |
| 12067 | 16-32483 | |
| 12074 | 16-32613 | |
| 12082 | 16-32542 | Dep.(mc) |
| **NP-tr–** | **(AEC File No. for Non-AEC Translations)** | |
| 884 | 16-31593 | Dep.(mc); $2.60(fs), $0.89(mf) JCL or OTS |
| 916 | 16-32406 | Dep.(mc); $6.60(fs), $2.30(mf) JCL |
| **NUMEC-P–** | | |
| 44 | 16-32101 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| **NYO–** | | |
| 2994 | 16-32110 | See CEND-123 |
| 9193 | 16-32484 | Dep.(mc); $3.60(fs), $1.13(mf) OTS |
| 9287 | 16-32398 | Dep.(mc); $8.60(fs), $3.17(mf) OTS |
| 9288 | 16-32277 | Dep.(mc); $5.60(fs), $1.97(mf) OTS |
| 9716 | 16-32578 | See MITNE-24 |
| 10032 | 16-32195 | J. Math. Phys. 3: 587-94(1962) |
| 10142 | 16-32007 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
| 10205 | 16-32362 | See MITNE-17 |
| 10243 | 16-32254 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 10246 | 16-32278 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 10448 | 16-31797 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| **OA:R–** | | |
| 27 | 16-32029 | See TID-16679 |
| **ORA–** | **(Misc.)** | |
| 03675-1-F* | 16-32270 | See DASA-1257 |
| **ORNL–** | | |
| 1339 | 16-32174 | Dep.(mc); $2.60(fs), $1.10(mf) OTS |
| 1531 | 16-32175 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 3280 | 16-31675 | Dep.; $0.75(OTS) |
| 3315 | 16-32485 | Dep.; $2.25(OTS) |
| 3329 | 16-32279 | Dep.; $2.00(OTS) |
| 3338 | 16-32363 | Dep.; $2.00(OTS) |
| 3342 | 16-31546 | Dep.; 7.60(fs), $2.39(mf) OTS |
| 3356 | 16-32620 | Dep.; $0.75(OTS) |
| **ORNL-TM–** | | |
| 222 | 16-31676 | Dep.(mc); $7.60(fs), $2.42(mf) OTS |
| 307 | 16-32025 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 309 | 16-32037 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 328 | 16-32080 | Dep.(mc); $3.60(fs), $1.25(mf) OTS |
| 331 | 16-31823 | Dep.(mc); $6.60(fs), $2.21(mf) OTS |
| 333 | 16-32026 | Dep.(mc); $3.60(fs), $1.40(mf) OTS |
| 334 | 16-32038 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 336 | 16-32119 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 339 | 16-32081 | Dep.(mc); $3.60(fs), $1.40(mf) OTS |
| 345 | 16-32027 | $2.60(fs), $1.01(mf) OTS |
| 353 | 16-32543 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| 354 | 32544 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 361 | 16-32028 | Dep.(mc); $8.60(fs), $2.96(mf) OTS |
| 363 | 16-31547 | Dep.(mc); $4.60(fs), $1.46(mf) OTS |
| 384 | 16-31677 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 391 | 16-32582 | Dep.(mc); $2.60(fs), $0.98(mf) OTS |
| **ORO–** | | |
| 487 | 16-32008 | Dep.; $0.50(OTS) |
| 538 | 16-32280 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 556 | 16-32494 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| 569 | 16-32281 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **PATENTS** | **(French)** | |
| 1,207,919 | 16-32597 | |
| 1,231,160 | 16-31786 | |
| 1,233,095 | 16-31952 | |
| 1,235,057 | 16-31787 | |
| 1,238,900 | 16-32598 | |
| 1,244,853 | 16-32557 | |
| 1,247,082 | 16-31788 | |
| 1,247,980 | 16-31789 | |
| 1,249,964 | 16-31790 | |
| 1,251,894 | 16-32558 | |
| 1,252,033 | 16-31805 | |
| 1,253,859 | 16-32599 | |
| 1,254,203 | 16-32559 | |
| 1,254,435 | 16-32560 | |
| 1,263,561 | 16-32561 | |
| 1,264,202 | 16-32562 | |
| 1,264,283 | 16-32563 | |
| 1,265,462 | 16-32564 | |
| 1,267,367 | 16-32565 | |
| 1,270,229 | 16-32566 | |
| **PATENTS–** | **(German)** | |
| 1,109,650 | 16-31688 | |
| **PATENTS** | **(Swiss)** | |
| 347,384 | 16-32600 | |
| 347,385 | 16-32601 | |
| 348,397 | 16-32077 | |
| 348,398 | 16-31689 | |
| 348,485 | 16-32462 | |
| **PNE–** | | |
| 103F | 16-31693 | Dep.; $1.00(OTS) |
| 130F | 16-31959 | Dep.; $3.00(OTS) |
| 150F | 16-31694 | Dep.; $1.25(OTS) |
| **PPAD–** | | |
| 455 E | 16-31824 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| **PR-P–** | **(Canadian)** | |
| 53 | 16-32176 | Dep.; $2.00(AECL) |
| **PWA–** | **(Non-AEC)** | |
| 1863 | 16-32039 | |
| **R–** | **(Misc.)** | |
| 61DSD13* | 16-32607 | |
| **RAD-SR–** | **(Non-AEC)** | |
| 62-19 | 16-32250 | |
| **RADC-TN–** | **(Non-AEC)** | |
| 61-188 | 16-31825 | OTS |
| **RCN–** | **(Dutch)** | |
| 8 | 16-31571 | Phillips Tech. Rev. 23: 69-82(1961-62) |
| **RESEARCH REPORT–** | **(Non-AEC)** | |
| EE-495 | 16-31825 | See RADC-TN-61-188 |
| **RM–** | **(Misc.)** | |
| 61TMP-96* | 16-31958 | See NP-12053 |
| 3288-PR* | 16-31960 | $1.60(fs) OTS |

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|---|---|---|
| **RTI–** | | |
| 2513-T1 | 16-32008 | See ORO-487 |
| **SB–** | (Non-AEC) | |
| 418(Suppl.1) | 16-32237 | $0.10(OTS) |
| 426(Suppl.1) | 16-32517 | $0.10(OTS) |
| 498 | 16-31999 | $0.10(OTS) |
| **SCR–** | | |
| 532 | 16-32152 | Dep.(nc); $3.60(fs), $1.25(mf) OTS |
| **SCTM–** | | |
| 249-61(14) | 16-31695 | Dep.(nc); $1.10(fs), $0.80(mf) OTS |
| **SGAE–** | (Austrian) | |
| 62/1B | 16-32608 | Dep.(nc) |
| 62/2B | 16-32545 | Dep.(nc) |
| 62/3B | 16-31640 | Dep.(nc) |
| **SM–** | (Misc.) | |
| 37427* | 16-32613 | See NP-12074 |
| 38892* | 16-31796 | See NP-12036 |
| **STI-PUB–** | (International Atomic Energy Agency) | |
| 20(Vol.I(p.193-206)) | 16-32123 | See AEC-tr-5362 |
| 42(Vol.I(p.37-45)) | 16-31836 | See AEC-tr-5367 |
| 42(Vol.I(p.139-41)) | 16-31837 | See AEC-tr-5370 |
| 42(Vol.I(p.363-77)) | 16-31835 | See AEC-tr-5366 |
| 42(Vol.II(p.297-303) | 16-31834 | See AEC-tr-5364 |
| 51(Vol.II(p.27-40)) | 16-32583 | See AEC-tr-5361 |
| **STL-TR–** | (Misc.) | |
| 60-0000-GR-332* | 16-32264 | See AD-272316 |
| **TDR–** | (Non-AEC) | |
| 169(3210-05)TN-1 | 16-32477 | See DCAS-TDR-62-145 |
| **TID–** | | |
| 3557(Suppl.1) | 16-32495 | Dep.; $3.00(OTS) |
| 3568(Rev.I) | 16-31352 | Dep.; $0.75(OTS) |
| 6408 | 16-32082 | Dep.(nc); $1.10(fs), $0.80(mf) OTS |
| 11164 | 16-32153 | Dep.(nc); $1.60(fs), $0.80(mf) OTS |
| 11429 | 16-32614 | Dep.(nc); $2.60(fs), $1.01(mf) OTS |
| 16550 | 16-32282 | Dep.(nc); $1.10(fs), $0.80(mf) OTS |
| 16552 | 16-32283 | $4.60(fs), $1.52(mf) OTS |
| 16557 | 16-32284 | Dep.(nc); $1.10(fs), $0.80(mf) OTS |
| 16558 | 16-32285 | Dep.(nc); $2.60(fs), $1.01(mf) OTS |
| 16566 | 16-32286 | Dep.(nc); $1.10(fs), $0.80(mf) OTS |
| 16581 | 16-32546 | Dep.(nc); $1.10(fs), $0.80(mf) OTS |
| 16593 | 16-31467 | Dep.(nc); $5.60(fs), $1.88(mf) OTS |
| 16597 | 16-32120 | Dep.(nc); $1.60(fs), $0.80(mf) OTS |
| 16608 | 16-31641 | Dep.(nc); $1.60(fs), $0.80(mf) OTS |
| 16641 | 16-32154 | Dep.(nc); $2.60(fs), $0.95(mf) OTS |
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